Construction Methods

August
1932

Hoover damsite where 730-ft. high concrete structure will rise in Black Canyon of Colorado River between Nevada (at right) and Arizona

oover Dam
Number

McGraw-Hill
Publishing Company, Inc.

ONTHLY REVIEW
FIELD PRACTICE
ND EQUIPMENT

Construction · Highways
· Engineering · Industrial

Important Tasks Performed by "HERCULES" (Red-Strand) Wire Rope on the Hoover Dam Project

The illustration on the left shows a shovel operated by the Lewis Construction Company on its contract for building a Railroad from Boulder City to the dam site. In the center is equipment operated by the Six Companies, Inc. On the right is work of R. G. Le Tourneau, Inc., on the highway they built to the site of the project.

Consider Its Service Record!

Ever since "HERCULES" (Red-Strand) Wire Rope was developed over 45 years ago it has been closely identified with big construction projects. It was but natural, therefore, for it to be given important duty on the world's largest irrigation project—The Hoover Dam.

There are reasons, of course, why "HERCULES" (Red-Strand) Wire Rope has been assigned such responsible roles. In the first place, it is made of acid open-hearth steel wire, and every wire used is first rigidly tested by us to make sure that it meets our exacting requirements. Manufacturing methods are also vital factors, for tension must be equalized on all wires and all strands.

Then type of construction is very important, and "HERCULES" (Red-Strand) Wire Rope is probably made in a wider range of constructions than any other wire rope on the market. These constructions include designs of Round Strand, Patent Flattened Strand, Non-Rotating, Preformed and Steel Clad types. These designs not only involve variations in the number, size and shape of the wires used, but also changes in the shape and lay of the strands; kind and construction of the core; and often times the normalizing, or setting, of the strands.

—And "HERCULES" (Red-Strand) Wire Rope has proved that it is just as economical on small jobs as on the big ones. Why not give it a chance to show you what it can do?

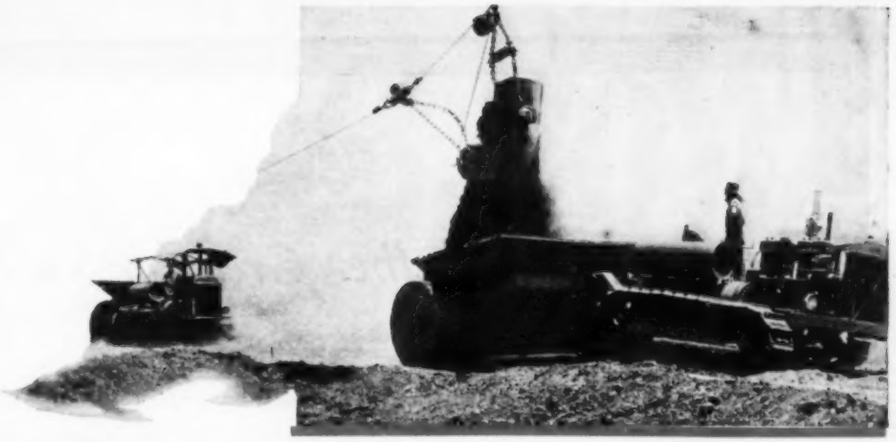
Made only by **A. Leschen & Sons Rope Co.** Established 1857
5909 Kennerly Avenue—St. Louis, Missouri

New York.....90 West St.
Chicago....810 W. Washington Blvd.
Denver.....1554 Wazee Street
San Francisco.....520 Fourth St.

1857 — SEVENTY-FIVE YEARS IN BUSINESS — 1932

CONSTRUCTION METHODS, August, 1932. Vol. 14, No. 8. Published monthly. McGraw-Hill Publishing Company, Inc., 330 West 42d Street, New York, N. Y. $1 per year. Central and South American countries and Foreign, $2 U. S. Currency, or 10 Shillings. Canada (including Canadian duty), $1.50. 10 cents per copy. Entered as second-class matter, October, 1926 issue, Vol. 8, No. 10, at the Post Office at New York, N. Y., under the Act of March 3, 1879. Printed in U. S. A.

The Editor Notes—



Hoover Dam Number

THIS number of *Construction Methods,* devoted exclusively to the Hoover dam, marks an important transition stage in the work on the Boulder Canyon project. As planned by the U. S. Bureau of Reclamation, the construction program involves three major phases:

Municipal Construction

The first covers the preliminary operations necessary for housing the engineering and construction personnel and their families at an isolated spot in the desert country of Nevada, and of providing transportation facilities in the form of new railway lines and highways to serve an area hitherto inaccessible. Immediately after the $49,000,000 contract for the Hoover dam had been awarded to Six Companies Inc., in March, 1931, work was concentrated on the creation of a modern municipality near the damsite. Today, Boulder City, with a population of nearly 5,000, and buildings of various types to the number of about 1,000, with paved streets, waterworks and sewers, is a reality.

River Diversion

With the job of city building done, the construction forces now are focusing their efforts on the second phase of the project, the diversion of the Colorado River around the damsite in order to provide a working area for erecting the 730-ft. high barrier of concrete which will be wedged in between the Nevada and Arizona canyon walls to impound the river flow. The outstanding construction feature of this second phase of the program is a group of four tunnels in rock, each about 4,000 ft. long, and of exceptional size—56 ft. in outside diameter, which will be reduced to a finished inside diameter of 50 ft. by a 3-ft. thick concrete lining. Further details on the driving of these immense tunnels are given in an article elsewhere in this issue. The immense size of the bores—each large enough to accommodate a five-story house—introduced special problems of drilling, blasting, mucking and lining, which have been solved by ingenious applications of equipment and methods.

When these tunnels are completed huge rockfill cofferdams will be placed across the river above and below the damsite, and the flow of the Colorado will be diverted through the huge concrete-lined conduits in the canyon walls.

Building the Dam

Then will begin the third and final phase of the project—the preparation of the foundation and the construction of the dam proper, calling for the placement of an unprecedented mass of concrete, 3,400,000 cu.yd. in the main structure, in addition to a million yards more in appurtenant works.

The project is noteworthy not only because of its size, but also, as President Bechtel of the contractors' organization points out in his statement on page 16, because of the diversity of work involved, the care required in planting the job and the necessity of close cooperative effort among all of the interests responsible for the successful completion of the project on time.

In no engineering project since the Panama Canal has there been such widespread interest among engineers and contractors the world over. In text and illustration, therefore, this issue assembles a few pages from the story of the Hoover dam, and indicates the progress—already about a year ahead of schedule—thus far made on the Reclamation Bureau's great project of flood control, irrigation and power development on the Colorado River.

CONSTRUCTION METHODS

A monthly review of modern construction practice and equipment

ROBERT K. TOMLIN, *Editor*

Editorial Staff

VINCENT B. SMITH NELLE FITZGERALD
J. I. BALLARD (San Francisco)

WILLARD CHEVALIER, *Publishing Director*

McGraw-Hill Publishing Company, Inc.
330 West 42d St., New York, N. Y.

For Lower Building Costs

DECLARING that the American public pays too much for housing that is poor in design, construction, and equipment, a group of nationally known architects, builders, dealers in building materials and equipment, engineers, and home economists offer detailed plans for the correction of this situation in the fifth volume of the final reports of the President's Conference on Home Building and Home Ownership, published last month. The recommendations of these building authorities form part of the complete program to raise the standard of American housing that was formulated by the President's Conference at its meeting in Washington last December. The essence of the proposed plan to lower costs is better organization of the building industry.

In the section on construction it is stated that efficient cost accounting, estimating, and scheduling of work are practiced by but few builders; such labor-saving devices and materials as portable forms, ready-mixed concrete, plaster mixers, floor-sanding machines, power drills, and paint-spraying equipment are used comparatively little; and ignorance of cost-saving materials now on the market is widespread. The authors urge all-year-round construction; less manufacture on the site and more in the factory; more efficient storage and handling of materials; standardization and simplification of materials such as lengths of lumber and sizes of brick; and constant research to improve materials and methods. At the same time they recommend the improvement of building codes to permit and encourage the use of desirable new materials and methods.

Whether Great or Small

DURING recent months *Construction Methods* has touched frequently upon the progress of work at the Hoover Dam. This issue is devoted wholly to that notable project, describing in word and picture much of the preliminary construction that has preceded work on the dam itself.

It will be obvious that few constructors ever will have occasion to build a Hoover Dam or any structure approximating it in magnitude, yet we should not let its size obscure the simplicity of the principles that must underlie its management. These are universal; they apply with equal force to every construction job whether great or small.

Every large project is but a combination of smaller projects, or else it is simply the application on a grand scale of principles and methods that are in use every day on ordinary work. The magnitude of the job simply multiplies the risk of loss through bad judgment or loose management, thereby putting a higher premium on wise planning and skillful execution.

In this issue Warren A. Bechtel, president o the Six Companies, Inc., reviews some of these basic principles. Here they are in a nutshell:

1. Close coordination of planning and effort between the contractors and the engineering staff.
2. Provision of a contractor's staff well-versed in the several varieties of work involved.
3. Thorough preliminary study and planning in order to plant the job for maximum economy and efficiency of operation.
4. Consultation during this planning with the field men who must be responsible for results, and with the manufacturers' engineers in order to insure the selection of equipment best adapted to the work in hand.

In every issue *Construction Methods* seeks to illustrate these principles at work on the everyday bread-and-butter construction that is being carried on by thousands of engineers and contractors the country over.

In this issue we take an opportunity to show them in action on a world-famous enterprise which, after all, differs from the others chiefly in that there is a whole lot more of it.

Willard Chevalier

Publishing Director

McGRAW-HILL PUBLISHING COMPANY, INC., 330 WEST 42d STREET, NEW YORK, N. Y.

CHICAGO, 520 N. Michigan Ave.

JAMES H. McGRAW, Chairman of the Board
MALCOLM MUIR, President
JAMES H. McGRAW, JR., Vice-Pres. and Treas.
MASON BRITTON, Vice-President
EDGAR KOBAK, Vice-President
H. C. PARMELEE, Vice-Pres. and Editorial Director
HAROLD W. McGRAW, Vice-President
C. H. THOMPSON, Secretary

CABLE ADDRESS: "MCGRAWHILL, N.Y."

Aldwych House, Aldwych,
LONDON, W.C. 2

Member A.B.P. *Member A.B.C.*

Copyright, 1932, by McGraw-Hill Publishing Company, Inc.

883 Mission St., SAN FRANCISCO

WASHINGTON, National Press Building
PHILADELPHIA, 1600 Arch Street
CLEVELAND, 501 Guardian Building
DETROIT, 2-257 General Motors Building
ST. LOUIS, 1556 Bell Telephone Building
BOSTON, 1427 Statler Building
GREENVILLE, S. C., 1301 Woodside Building
LOS ANGELES, 339-340 Chamber of Commerce Building

STABILITY-SPEED-POWER

Six Link-Belt draglines are working on this Southwestern Outfall Sewer Job, Louisville, for Torson Construction Co., who have purchased 10 Link-Belts since 1924.

YOU have always known the Link-Belt as a strong, substantial machine—heavy-duty built throughout. It is at home in handling rock, hardpan, cemented gravel, lava rock and other materials where real endurance is required.

Remember, however, that in the matter of capacity the Link-Belt has also set records. Compare its power, its speed, its all-around ability to do fast work - - - big yardages on tough jobs.

And remember also that its efficiency is not merely a matter of this power or ruggedness or speed, or of any other *single* feature - - - but a combination of all of them properly co-ordinated in the one design. This means low-cost performance. From ¾ to 2½ yards capacity, heavy-duty. Send for Catalog 1095.

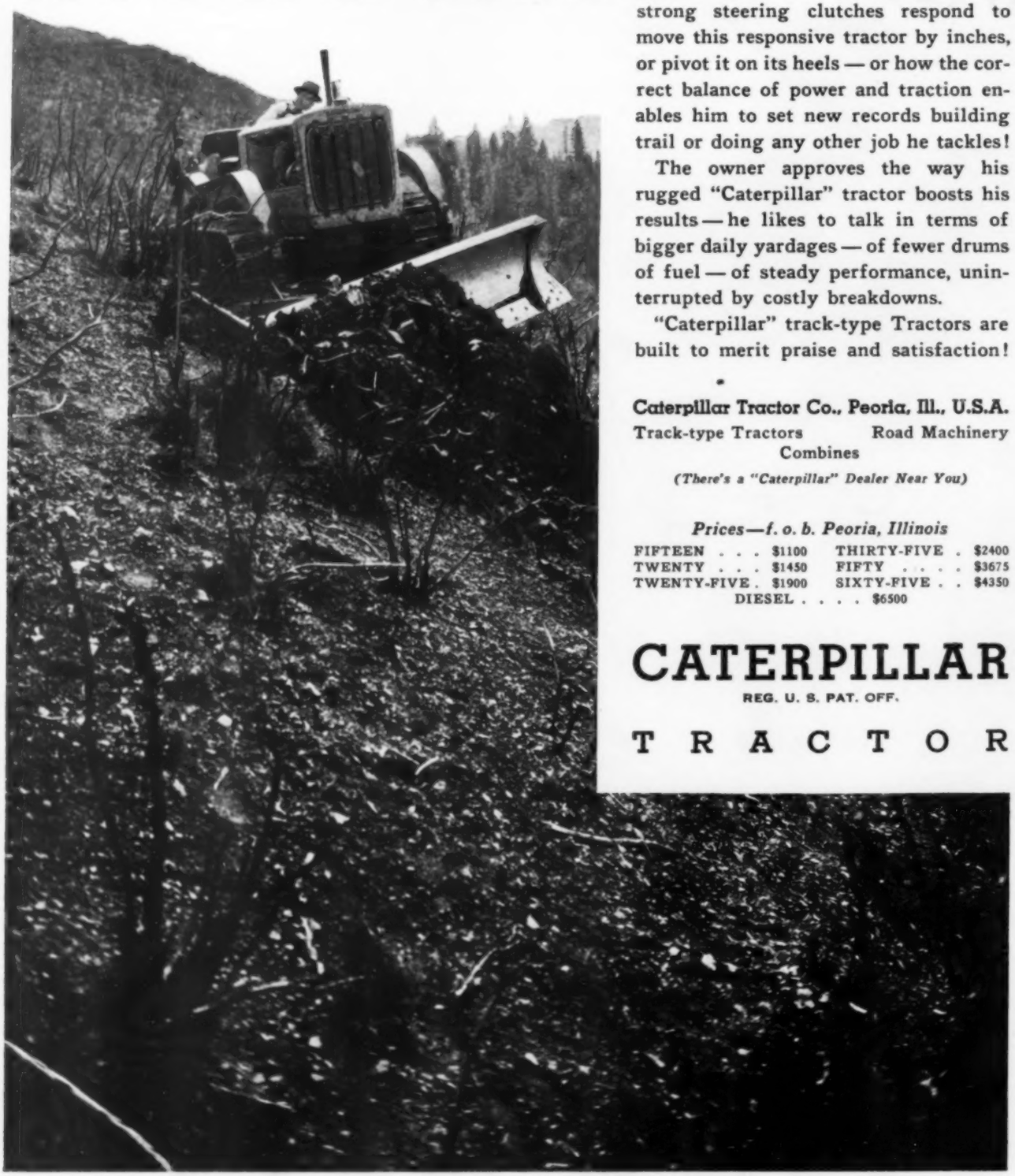
LINK-BELT COMPANY
300 West Pershing Road, Chicago
Offices and Distributors in All Principal Cities

LINK-BELT

SHOVELS CRANES DRAGLINES

4559-A

Earning the driver's pride —the owner's APPROVAL



THE Fifty's driver tells you how those broad tracks travel safely on perilous grades — how the "Caterpillar's" big, strong steering clutches respond to move this responsive tractor by inches, or pivot it on its heels — or how the correct balance of power and traction enables him to set new records building trail or doing any other job he tackles!

The owner approves the way his rugged "Caterpillar" tractor boosts his results — he likes to talk in terms of bigger daily yardages — of fewer drums of fuel — of steady performance, uninterrupted by costly breakdowns.

"Caterpillar" track-type Tractors are built to merit praise and satisfaction!

•

Caterpillar Tractor Co., Peoria, Ill., U.S.A.

Track-type Tractors Road Machinery
Combines

(There's a "Caterpillar" Dealer Near You)

Prices—f. o. b. Peoria, Illinois

FIFTEEN . . .	$1100	THIRTY-FIVE .	$2400
TWENTY . . .	$1450	FIFTY	$3675
TWENTY-FIVE .	$1900	SIXTY-FIVE . .	$4350
DIESEL	$6500		

CATERPILLAR

REG. U. S. PAT. OFF.

TRACTOR

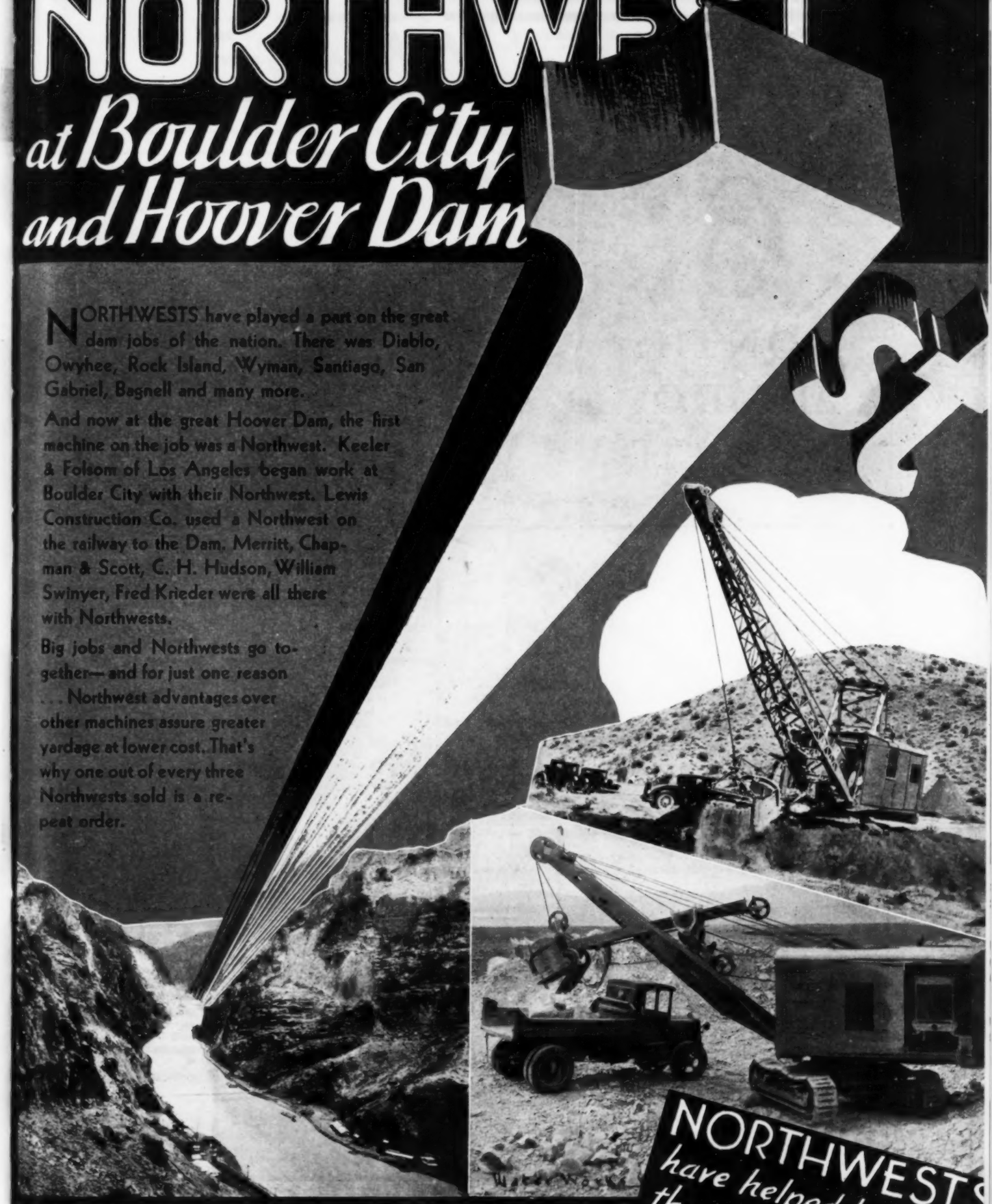
NORTHWEST

at Boulder City and Hoover Dam

NORTHWESTS have played a part on the great dam jobs of the nation. There was Diablo, Owyhee, Rock Island, Wyman, Santiago, San Gabriel, Bagnell and many more.

And now at the great Hoover Dam, the first machine on the job was a Northwest. Keeler & Folsom of Los Angeles began work at Boulder City with their Northwest. Lewis Construction Co. used a Northwest on the railway to the Dam. Merritt, Chapman & Scott, C. H. Hudson, William Swinyer, Fred Krieder were all there with Northwests.

Big jobs and Northwests go together—and for just one reason . . . Northwest advantages over other machines assure greater yardage at lower cost. That's why one out of every three Northwests sold is a repeat order.



NORTHWESTS have helped build the greatest dams in Amer

NORTHWEST ENGINEERING COMPANY

The world's largest exclusive builders of gasoline, oil burning and electric powered shovels, cranes and draglines

1700 Steger Building 28 East Jackson Boulevard Chicago, Illinois, U. S. A.

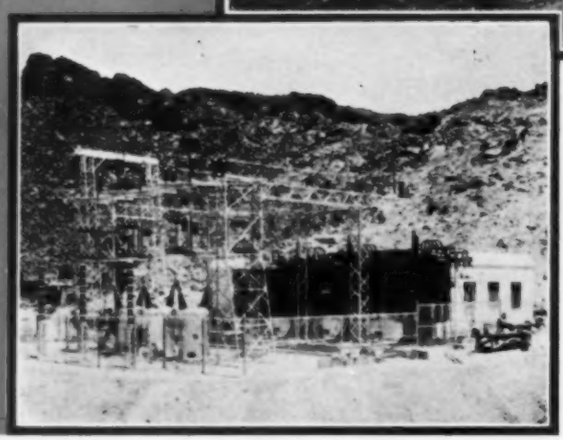
TIME

6 MONTHS AHEAD OF SCHEDULE

One of the nine Marion shovels working on approaches, roads and diversion tunnels. The new Westinghouse MC Shovel Motors, with Variable Voltage Control are an important factor in helping these shovels maintain an average loading of 121 cu. yd. per hour, with individual performances over 200 cu. yd. per hour (under severe trucking conditions).

This Marion dragline, powered by the new Westinghouse MC Shovel Motor and Variable Voltage Control, has loaded a 10-car train (350 cu. yd.) of concrete aggregate in 40 minutes.

The new Westinghouse Totally-enclosed Fan-cooled CS Motors and a Westinghouse centralized remote control system are important factors in the production progress made by the aggregate plant.



Four Westinghouse 5,000 Kv-a. Transformers convert incoming power to the voltage requirements of the construction work.

HOOVER DAM CONTRACTORS HAVE MET THE CHALLENGE

WITH

ELECTRIFIED EQUIPMENT

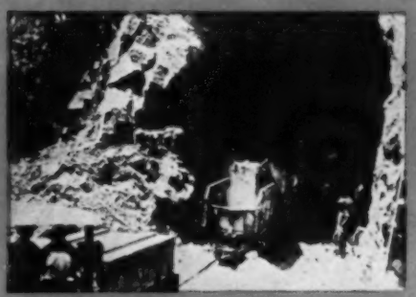
WITH time-delay penalty chalked at $3,000 a day, methods, men and machines *must* be organized, co-ordinated . . . dependable. That challenge has been met by Six Companies, Inc. at Hoover Dam. The record of work completed six months ahead of schedule speaks for the excellence of management and equipment.

Machinery electrified by Westinghouse has played an important part in this achievement. Powering shovels, such equipment as mucking machines, locomotives, aggregate and cement-mixing plants, water treatment apparatus and air compressors, and in electric power distribution Westinghouse apparatus has been a vital factor in meeting time's challenge—in assuring dependability and readiness for *action* at low operating costs.

The illustrations show some of this equipment at work.

Regardless of the size of the project, electrification by Westinghouse assures maximum work done in minimum time and at lowest cost.

An engineer in our nearest office will furnish you with complete information on Westinghouse equipment for the construction field. The coupon is for your convenience.



Hauling and conveying in the construction of the tunnel adits . . . the job handled by Baldwin-Westinghouse 10-ton Locomotives and Conway Mucking Machines, powered by Westinghouse 50-hp. Linestart Motors and "De-ion" Linestarters.

Westinghouse-powered Ingersoll-Rand compressors speed up drilling operations.

The huge water-treating system for the aggregate plant and for Boulder City is equipped with Westinghouse Motors and Control.

The concrete-mixing plant, with an output of 170,000 cu. yd. per month, is equipped throughout with Westinghouse Motors and Control.

Westinghouse

Quality workmanship guarantees every Westinghouse product

MAIL THE COUPON

Westinghouse Electric & Manufacturing Company
Room 2-N—East Pittsburgh, Pa.

Please send ☐ L. 20525 (the new MC Shovel Motor) ☐ L. 20384 (the new Fan-cooled CS Motor) ☐ L. 20394 (Linestarters).

Name .....

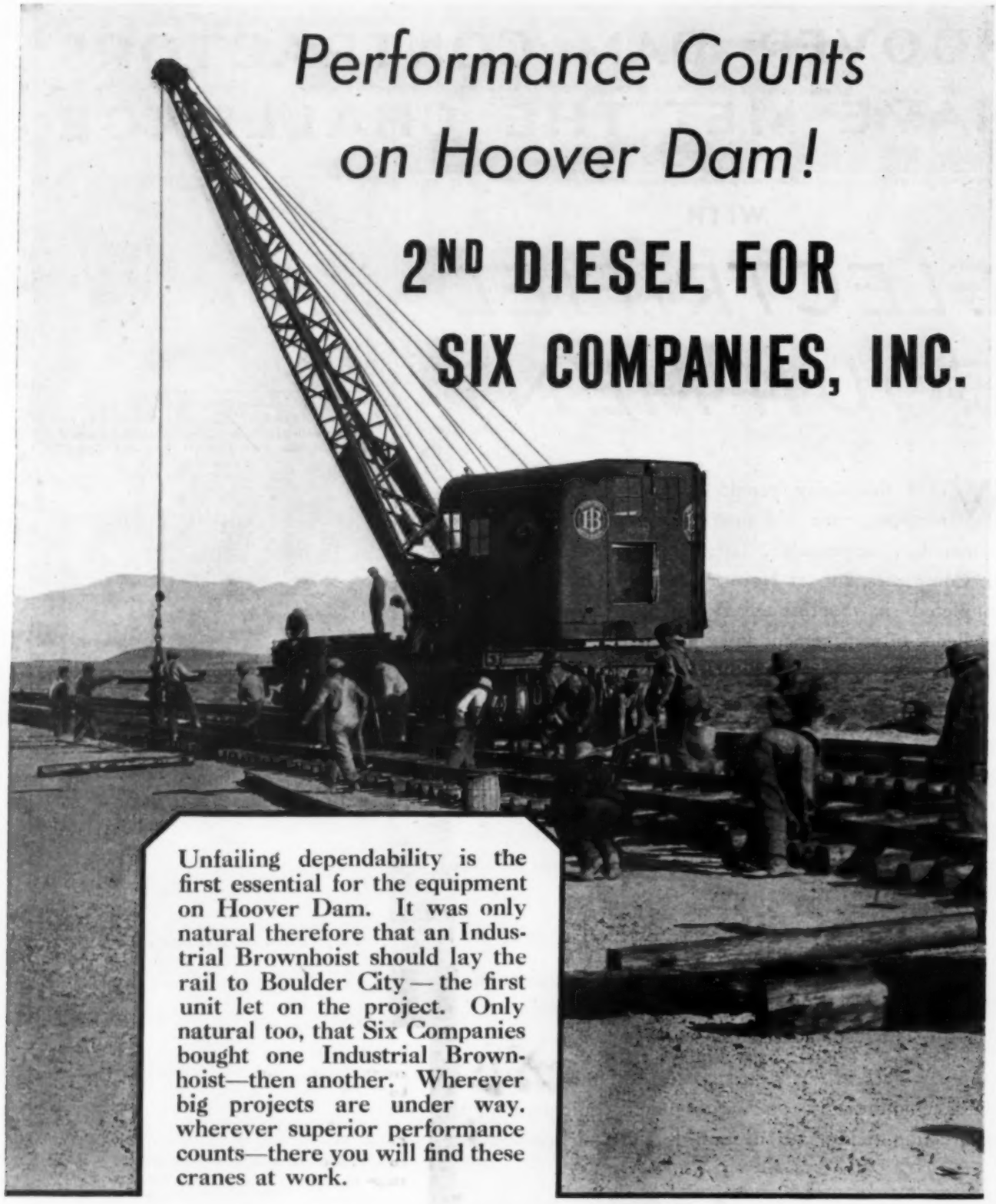
Company .....

Address .....

City ..... State ..... CM 8-32

Performance Counts on Hoover Dam!

2ND DIESEL FOR SIX COMPANIES, INC.



Unfailing dependability is the first essential for the equipment on Hoover Dam. It was only natural therefore that an Industrial Brownhoist should lay the rail to Boulder City — the first unit let on the project. Only natural too, that Six Companies bought one Industrial Brownhoist—then another. Wherever big projects are under way. wherever superior performance counts—there you will find these cranes at work.

Industrial Brownhoist Corporation, General Offices. Bay City, Michigan

District Offices: New York, Philadelphia, Chicago, Cleveland

INDUSTRIAL BROWNHOIST

CITIES SERVICE

CITIES SERVICE OILS

ONCE - ALWAYS

"Speed and Power are necessary for economic construction," say the Struck Construction Company of Louisville, Ky.

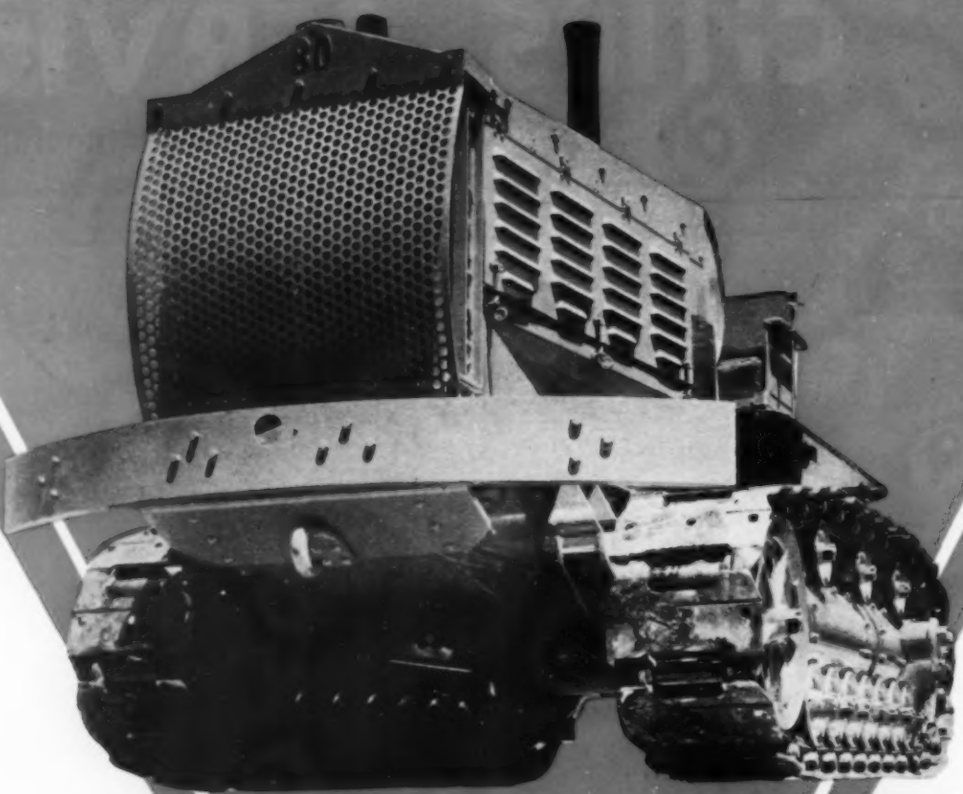
— and that doubtless explains why they turned to Cities Service for the petroleum products needed in the construction of this new $4,000,000 office building for the state of Ohio.

Contractors everywhere are finding that, whatever their need in gasolenes, oils, or greases, there's a Cities Service product to meet that need.

Let them help you on your next job.

"IF IT'S CITIES SERVICE—IT HAS TO BE GOOD!"

CLETRAC *Helps Speed*

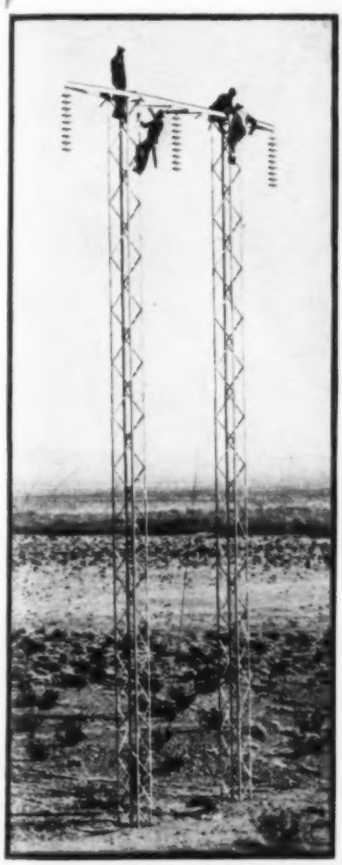


225 Mile Transmission Line in 225 Days

CLETRAC

Helps Give Speed with Economy

Power to HOOVER DAM



HEAVY going over sandy desert and mountainous grades. Hard pulls amid heat and arid, thirsty air.

225 miles of transmission line to be built in 240 days contract time—to bring the power that would release the countless activities of the giant project.

The job was completed in 225 days—15 days under schedule. Contributing materially to this splendid performance were two Cletracs which operated in laying conductor cable. These Cletracs brought their economical, sturdy reliability, their ability to keep going under staggering conditions—to this difficult job.

Pulling special cable reel trailers, the tractors were able to operate in extremely rough sections, paying out cable in the proper position for hoisting to the tower tops.

There were no roads much of the way, but Cletrac carries its own road. Grades were terrific in some places, but Cletrac doesn't mind severe grades.

Cletrac has power. It has endurance, safety, perfect control under all conditions. It will go places where you couldn't ride a horse. Whether it is a special job like this, or road construction, earth moving or heavy haulage, Cletracs will afford maximum speed, highest economy. Sizes, from the big powerful "80" to the light, speedy "15."

Let the Cletrac distributor show how Cletracs are built to conquer the tough jobs—and to give economy on all sorts of work. See him or write for catalogs.

CLETRAC Crawler Tractors sold and serviced in this territory by THE AUSTIN-WESTERN ROAD MACHINERY CO.

The Cleveland Tractor Co.

19319 EUCLID AVE. CLETRAC REG. U.S. PAT. OFF. CRAWLER TRACTORS CLEVELAND, OHIO

"We simply haven't the *room* for any guesswork!"

"AMONG other things, the specifications call for perfect concreting . . . on a very tight time-schedule. We can't afford to lose any of the cement . . . or even take chances on collecting and returning bags. We're in the season of sudden and frequent showers of rain, too. Our estimate on this job calls for a certain amount of cement at a definite price. It's got to cost exactly what we figured . . . or less.

"These are the reasons why, this time, the stuff is coming to us in Multi-Wall *Sewn* Paper Bags."

Construction, these days, can be profitably conducted only with the most accurate kind of pre-figuring. Everything is being done at such close prices that an apparently small "variable" can spell the whole difference between red ink and black. And so the proportion of cement and similar rock products shipped in Multi-Wall Sewn Paper Bags is steadily rising.

The Associated Manufacturers of
MULTI-WALL *SEWN* PAPER BAGS
60 East 42nd Street, New York, N. Y.

ARKELL AND SMITHS
Canajoharie, N. Y.

BATES VALVE BAG CORP.
60 E. 42nd St., New York, N. Y.

BEMIS BRO. BAG CO.
Peoria, Ill.

THE JAITE COMPANY
Jaite, Ohio

THE THOS. PHILLIPS CO.
Akron, Ohio

THE RAYMOND BAG CO.
Middletown, Ohio

TAGGART BROS. CO., INC.
60 E. 42nd St., New York, N. Y.

UNIVERSAL PAPER BAG CO.
New Hope, Pa.

THE VALVE BAG CO.
60 E. 42nd St., New York, N. Y.

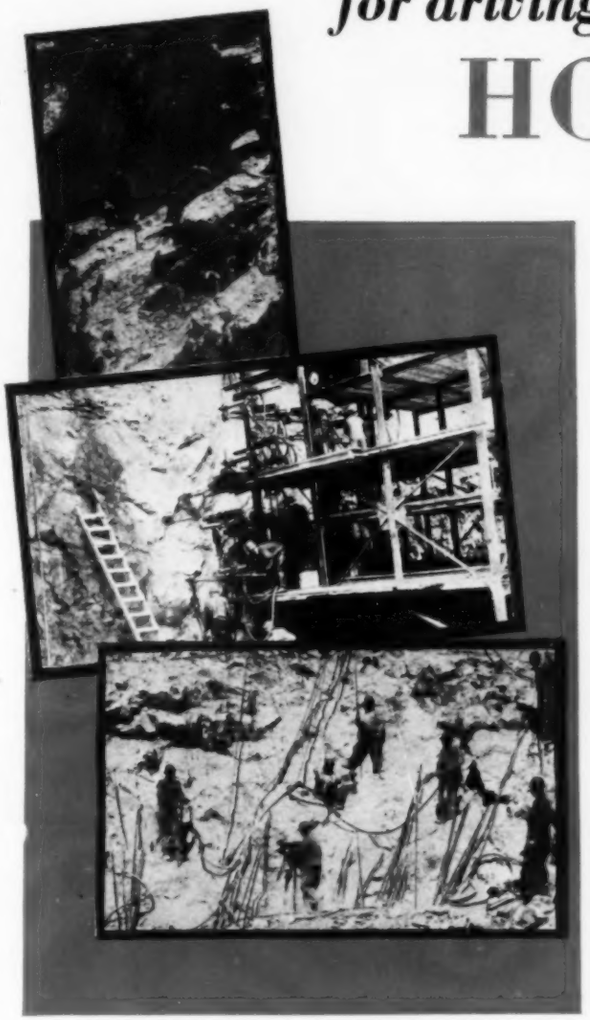
The SUPREME RECORD FOR ROCK DRILL STEEL!

Six Companies, Inc., standardized on

CRUSCA

for driving the four diversion tunnels

HOOVER DAM



THE enlarging work of the diversion tunnels, each 4,000 ft. long and 56 ft. in diameter, was carried on from the portals, providing eight faces for attack. In each heading, a drill carriage or "jumbo" mounted on a truck chassis was used. Each carriage handled 26 drifter drills at once. So huge were the tunneling operations, after the pioneer headings were holed through, that a 2½-yd. electric shovel could be used for loading the blasted rock into trucks.

The tunnels are the largest ever driven for a comparable distance. A total of 1,563,000 cu.yd. of hard rock was removed in driving them. The magnitude of the tunnel work is indicated by the fact that 15,000 miles of drill holes were required in the cycle of drilling, shooting and mucking and when it is considered that the Holland vehicular tunnels are only about 31 ft. in diameter, an idea of the enormity of this project may be appreciated.

This is a new record for tunnel driving and is the supreme record for "Crusca" drill steel—used exclusively on this work.

CRUCIBLE STEEL COMPANY *of* AMERICA

General Offices: Chrysler Bldg., New York

BRANCH OFFICES AND WAREHOUSES

Atlanta	Buffalo	Cleveland	Hartford	New Haven	Pittsburgh	Seattle	St. Paul	Toronto
Baltimore	Chicago	Denver	Indianapolis	New York	Providence	Springfield	Syracuse	London
Boston	Cincinnati	Detroit	Milwaukee	Philadelphia	San Francisco	St. Louis	Montreal	Tokio

CHAIN BELT COMPANY

extends its congratulations to

SIX COMPANIES, INC.

On the sensational engineering already achieved—the forerunner of even greater things to come at Hoover Dam—the Chain Belt Company congratulates Six Companies, Inc., its Officers and Men who are successfully carrying out this gigantic undertaking of the West.

The Chain Belt Company takes justifiable pride in the fact that Rex-Stearns Timken Idlers and Rex Moto-Mixers were waiting for these advanced construction methods and were selected for the transportation of aggregates and concrete to its final placements in this tremendous structure.

CHAIN BELT COMPANY
1664 West Bruce Street, Milwaukee, Wis.
Established 1891—Branch Offices in 17 Cities

100 tons of Rex-Stearns Timken Idlers are in operation in the aggregate and mixing plants

14 Rex Moto-Mixers are working here. The Rex Moto-Mixer detached from motor truck is moving by the air route to the pouring platform

Construction Methods

ESTABLISHED 1919—MCGRAW-HILL PUBLISHING COMPANY, INC.

ROBERT K. TOMLIN, *Editor*

VOLUME 14 NEW YORK, AUGUST, 1932 NUMBER 8

Ewing Galloway Photo

Scope of BOULDER CANYON Project

UNDER the terms of the Boulder Canyon Project Act, signed by the President Dec. 21, 1928, after an 8-year legislative battle, the Secretary of the Interior is authorized to construct the Boulder (later re-named the Hoover) dam, power plant and appurtenant works in Black Canyon where the Colorado River forms the boundary between the states of Nevada and Arizona. In addition to the dam, the act provides for the construction of an all-American canal to take water diverted from the Colorado River below the dam and deliver it a distance of about 80 mi. to a connection with the irrigation distribution system serving the Imperial Valley in California.

Subject to subsequent appropriation acts, a total expenditure of $165,000,000 is provided for in the Boulder Canyon Act, covering the following major items:

Dam and reservoir	$70,600,000
1,000,000-hp. development	38,200,000
All-American canal	38,500,000
Interest during construction	17,700,000
Total	$165,000,000

The purposes of the project are: (1) Flood control and general river regulation; (2) irrigation; (3) power development; (4) silt control; and (5) domestic water supply. Below the Hoover dam there is a total irrigable land area in Nevada, Arizona and California of about 2,000,000 acres.

The reservoir formed by the Hoover dam, which will rise to a height of 730 ft. above the lowest point of its foundation, will be 115 mi. long and will have a capacity of 30,500,000 acre-ft. The installed capacity of the hydro-electric power plant will be about 1,000,000 hp. and the continuous firm power output will be about 650,000 hp. The time estimated for the completion of the project is 7 years.

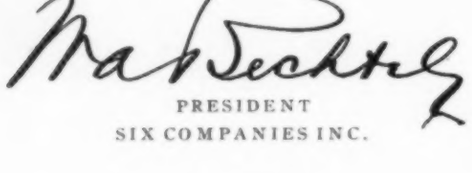
As foreseen by Secretary Ray Lyman Wilbur, of the Department of the Interior, the construction of the Hoover dam "will signalize our national conquest over the Great American Desert. With dollars, men and engineering brains we will build a great national resource. We will make new geography and start a new era in the Southwestern part of the United States."

MR. BECHTEL, executive head of the consolidated organization of six contracting companies which is building the Hoover dam, is a Western contractor of long and varied experience. He is a past-president of the Associated General Contractors of America

Construction Problems at Hoover Dam

And How They Are Being Handled

BY



PRESIDENT
SIX COMPANIES INC.

IN FAR GREATER MEASURE than is common even on large-scale construction projects the building of the $49,000,000 Hoover dam is a joint enterprise, depending for its success upon cooperative effort. No single master mind is responsible for its design or construction. Instead, it is the product of many minds and many kinds of thinking.

This great joint enterprise for the supply of water and power from the Black Canyon of the Colorado River demands, first of all, a close coordination of effort between builder and owner—Six Companies Inc., and the Federal Government, represented by the U. S. Bureau of Reclamation. Next, comes a relationship not ordinarily encountered on construction work—a consolidation of six independent contracting organizations into a single body, involving special problems of organization and management in order to capitalize to the fullest the collective experience and resources of its component parts. Third, and finally, there is the important relationship between the constructors and the makers of the equipment and materials required to build this greatest of public works projects for the storage of water and the generation of power.

Equipped, six-fold, with a personnel of broad and varied experience, the constructors realized, at the outset, that the planting of the job—the selection of the right types, sizes and quantities of equipment and the coordination of the operations of the individual mechanical units—would be an all-important factor in insuring the maintenance of required progress schedules. Consider a few of the estimated quantities involved in building the world's largest dam:

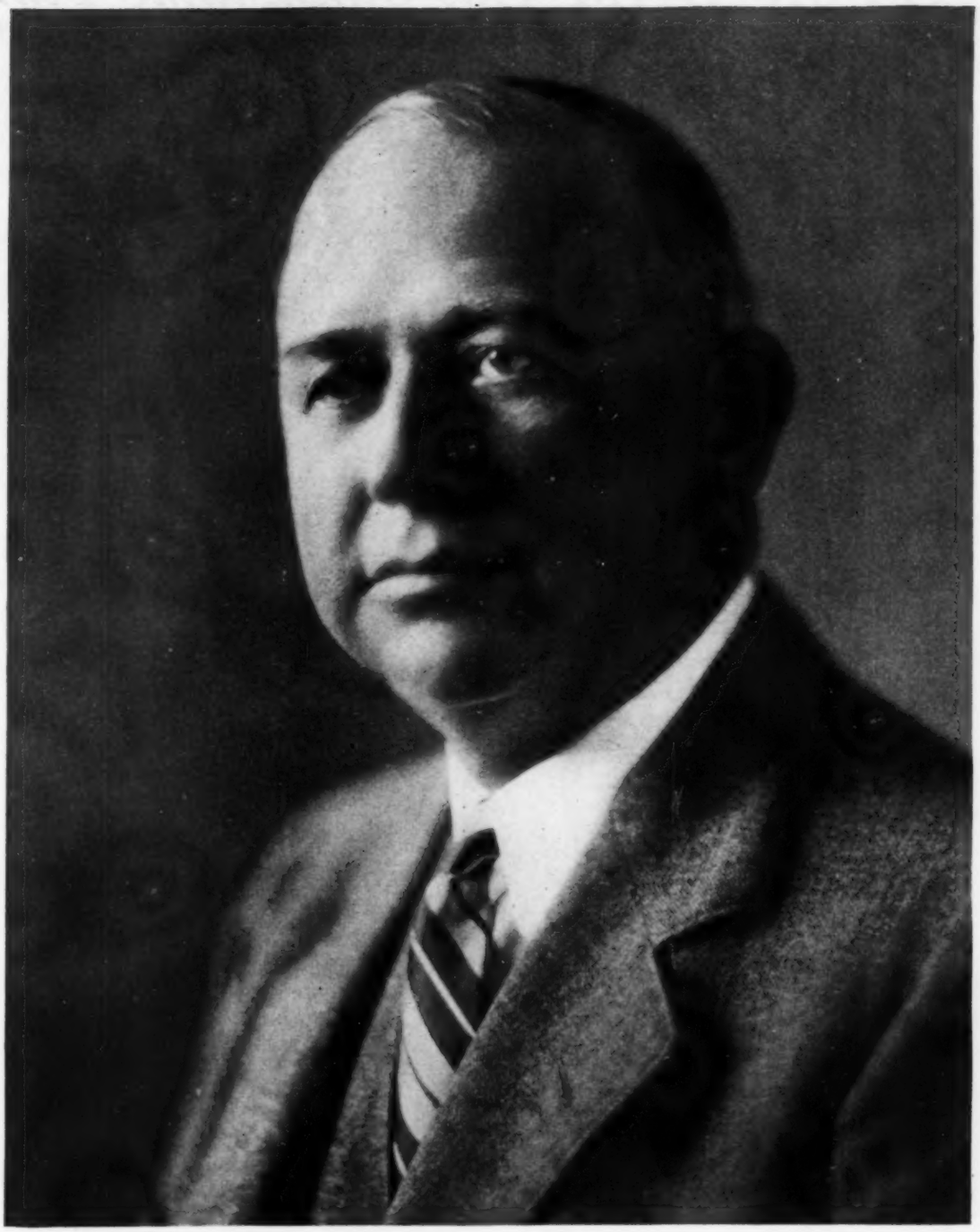
1,883,000 cu.yd. of rock excavation in diversion, spillway and penstock tunnels; 4,156,000 cu.yd. of excavation other than in tunnels; 3,400,000 cu.yd. of concrete in the main body of the dam; 893,000 cu.yd. of concrete for other purposes, including tunnel lining; 35,000,000 lb. of steel reinforcement and rails.

No precedent existed for a construction plant set-up capable of producing and handling such enormous quantities of materials. Mere capacity of plant, however, was only one of the major considerations in laying out the job. The Hoover damsite on the Colorado River is in desert country, far removed from sources of equipment supply. In all decisions affecting the choice of machinery, therefore, great stress was placed on its dependability and trustworthiness in service, for a breakdown at one point would mean a halt in the train of interrelated production operations, all closely coordinated to meet the requirements of a rigid time schedule.

Popularly referred to as the building of the Hoover dam the project actually involves almost every type of construction that engineers design. Before any work could be done on the main structure in the Colorado River Canyon a huge program of preliminary construction had to be undertaken. It was necessary, first, to create in the Nevada desert a full-sized city to house the engineering and construction personnel. This meant the building of houses, a water supply system, sewers, streets and the other facilities required by a modern municipality. In addition, transportation to the damsite had to be provided by new railroad and highway construction. Power had to be brought in by a long transmission line.

The scope of activities is almost unlimited, calling for every kind of specialized engineering and construction knowledge and skill. Nevertheless, the consolidated construction experience of the personnel in the six companies constituting the contractor's organization, supplemented by the engineering resources of the Reclamation Bureau's staff, are proving adequate to cope with the many and varied problems that present themselves for solution.

In the matter of plant selection and layout the contractor was fortunate in being able to utilize the experience and advice of executives, superintendents and field men of all of the six units constituting



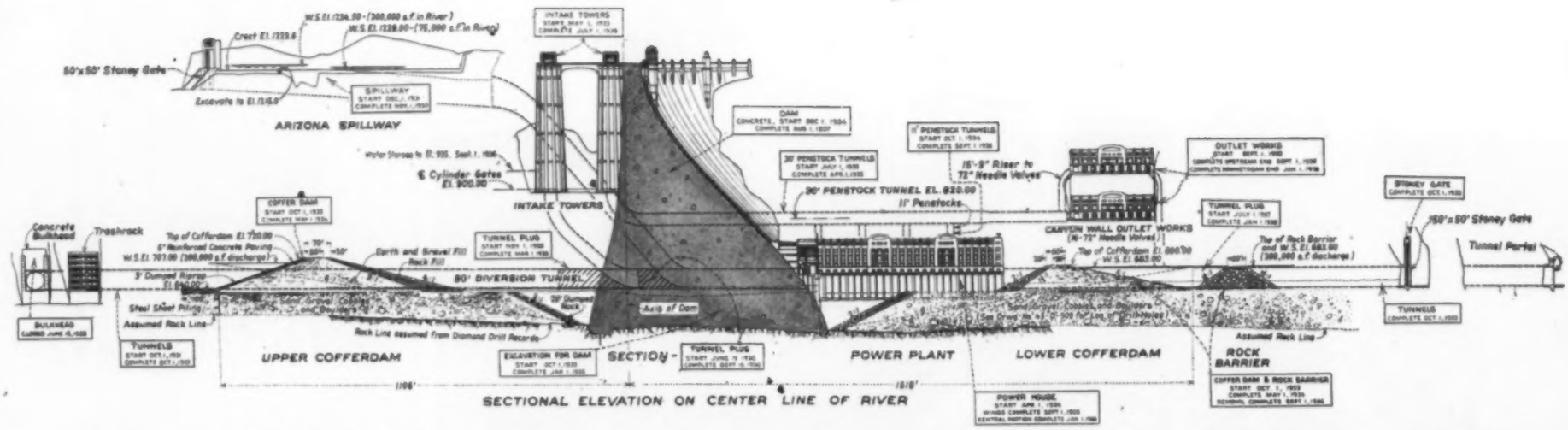
WARREN A. BECHTEL

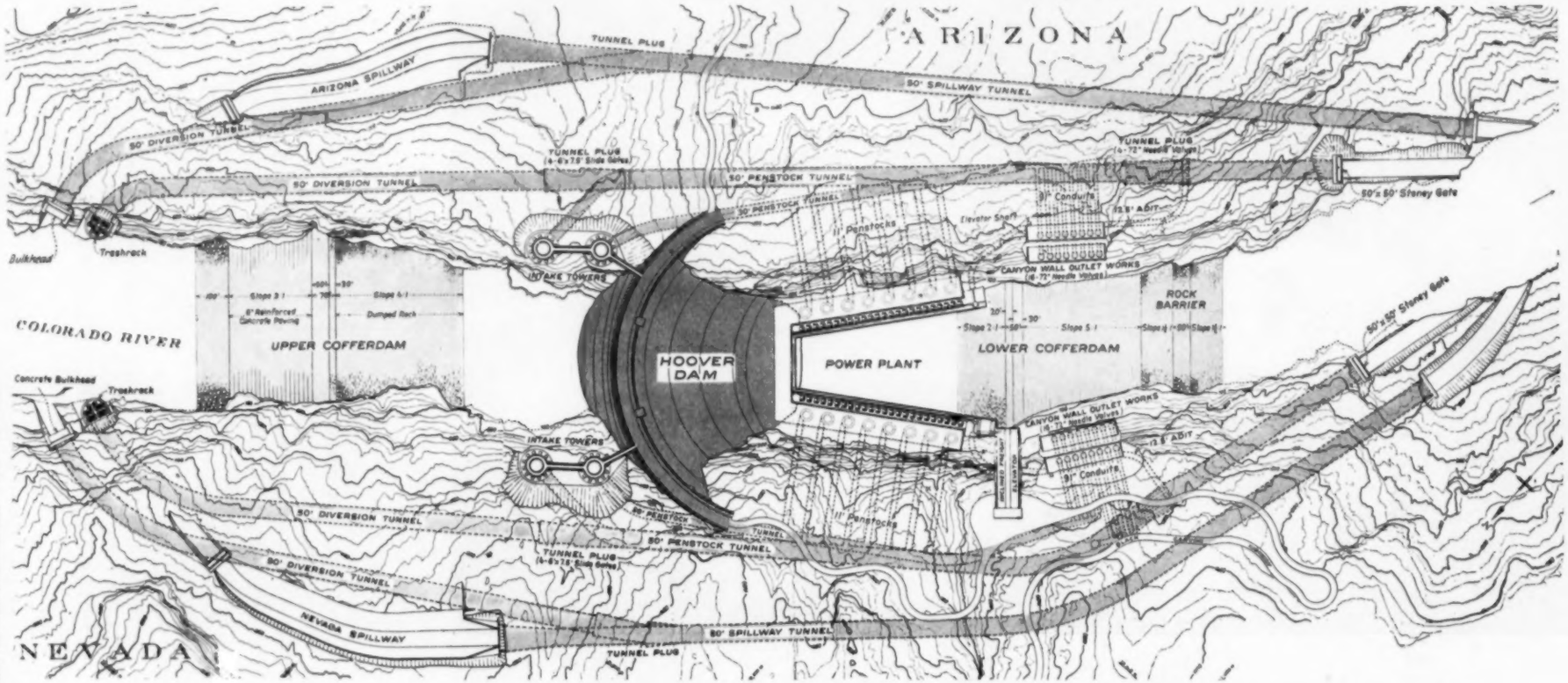
the Hoover dam organization, in addition to design, installation and operating data supplied by the equipment manufacturers, who sent specialists to the job to assist in planning and erecting the plant.

The resulting plant set-up, therefore, is not the product of a czar-like, one-man decision but rather represents the consolidated thought and recommendation of scores of construction specialists in various ranks of responsibility, all qualified by past experience in field or shop to offer reliable counsel. In planning and planting the job the contractor adhered to a policy of inviting from every man in the consolidated organization, whether an officer or an employee, suggestions and criticisms designed to aid in reaching a final decision as to the best methods and equipment for doing the job.

The work is now advancing in full stride, well ahead of scheduled progress. In carrying it to completion the aim of the contracting organization, with the close cooperation of the Government's engineers and the manufacturers of equipment and materials, will be to produce a structure that will stand for all time as a concrete embodiment of construction skill, integrity and responsibility.

HOOVER DAM *Has Outstanding Features*





PLAN AND CROSS-SECTION AT DAMSITE. Major features of project include 730-ft. high dam, four 50-ft. diameter concrete-lined diversion tunnels, spillways, 3-ft. diameter penstock tunnels, U-shaped power plant, outlet works, two cofferdams and intake towers.

of DESIGN AND CONSTRUCTION

AS DESIGNED by the U. S. Bureau of Reclamation, the Hoover dam, of the arch-gravity type, 730 ft. high from lowest point of foundation to crest, 650 ft. thick at the base and 1,180 ft. long on top, will contain the largest single mass of concrete ever placed—3,400,000 cu.yd.—with an additional 1,000,000 cu.yd. of concrete entering into the construction of appurtenant works, such as diversion tunnel linings, spillways, inlet and outlet structures and power house. This world's largest and highest dam in the Black Canyon of the Colorado River between Nevada and Arizona will form a lake 115 mi. long and 582 ft. deep, with a storage capacity of 30,500,000 acre-ft.

Purpose of Project—The purpose of the Boulder Canyon project, which, in addition to the Hoover dam and power plant, includes an 80-mi. all-American canal to deliver Colorado River water to the Imperial Valley in California, is fivefold: flood control and general river regulation, irrigation, silt control, power development and domestic water supply.

Construction Features—As indicated in the accompanying drawing the main construction features of the project are: (1) The dam proper. (2) Four diversion tunnels in rock, each about 4,000 ft. long and 56 ft. in diameter, lined with a 3-ft. thickness of concrete to produce a finished inside diameter of 50 ft.; these tunnels will divert the flow of the Colorado River past the dam during construction and will later serve permanently as penstocks and spillway conduits. (3) Two rock-fill cofferdams, one on the upstream and the other on the downstream side of the dam. (4) Four intake towers each 30 ft. in diameter. (5) Four outlet valve houses. (6) Two overflow spillways connected by inclined shafts with the diversion tunnels. (7) A U-shaped power house containing from 12 to 16 hydro-electric generating units. (8) An inclined freight elevator guide structure on the slope of the canyon wall immediately downstream from the power house on the Nevada side of the river.

Contract Award—After bids had been opened March 4, 1931, a contract for $48,890,995, covering the construction of the dam, power house and appurtenant works was awarded March 11, 1931 to Six Companies Inc., a consolidation of the following six Western contracting organizations: Utah Construction Co., Bechtel & Kaiser, MacDonald & Kahn Co., Morrison-Knudsen Co., J. F. Shea Co. and Pacific Bridge Co. Although the contract for construction is for the largest sum of any signed by the Federal Government, it does not represent the total cost of the work, as the U. S. Government will supply to the contractor many of the basic materials of construction, including cement, steel reinforcement, metal pipe and fittings, gates and valves, structural steel and piling.

River Diversion Works—The construction work is divided naturally into two parts, the first involving the diversion of the Colorado River and the second the building of the dam proper and the power plant. The damsite will be contained within an area protected by an upstream and a downstream cofferdam of the earth and rock-fill type. The upper cofferdam will have a height of about 80 ft., with steel sheet piling forming a watertight cutoff along its upstream toe. The downstream dam will be protected from eddy action by a rock barrier.

Each of the four diversion tunnels is 4,000 ft. long and 56 ft. in outside diameter, reduced to a 50-ft. finished inside diameter by a 3-ft. thick concrete lining. Methods of driving these tunnels are described in detail in an article on p. 24. The bores require a total of about 1,563,000 cu.yd. of rock excavation in tunnel and 400,000 cu.yd. of rock excavation in open cut.

The Dam—The huge dam, built with its axis on curve of 500-ft. radius, has a cutoff trench along its upstream toe. To insure watertightness the foundation is to be drilled and grouted under pressure through holes spaced at 5-ft. intervals. Drainage of the structure is provided for by a system of galleries connecting with conduits discharging at the downstream side of the dam.

Construction Quantities for HOOVER DAM

Open cut excavation	1,800,000 cu.yd.
Tunnel and shaft excavation	1,900,000 cu.yd.
Earth and rock fill, cofferdams	1,200,000 cu.yd.
Concrete	4,400,000 cu.yd.
Grout	228,000 cu.yd.
Drill holes, grout and drainage	290,000 lin.ft.
Reinforcement bars	5,500,000 lb.
Small pipe and fittings	1,900,000 lb.
Large metal conduits	32,500,000 lb.
Structural steel	10,600,000 lb.
Gates, hoists, etc.	20,000,000 lb.

Specifications covering the mass concrete include several noteworthy features. To provide for expansion and contraction the concrete in the body of the dam will be placed in columnar blocks, 50x50 ft. in plan, poured in lifts of about 5 ft. The setting heat of the concrete in excess of 72 deg. F. will be dissipated by a system of 800,000 lin.ft. 2-in. piping embedded in the dam and carrying circulating streams of water cooled by a refrigerating plant. The upstream face of the dam will be finished with a 1-in. gunite surface.

Power Plant—The power plant, just below the downstream face of the dam, will be a U-shaped concrete structure with one 500-ft. leg on each side of the river. Each of the two wings of the building will house 6 or 8 power generating units.

Spillways—On each side of the river is a spillway, consisting of a 50x50-ft. Stoney gate, a concrete ogee overflow crest about 700 ft. long and a concrete-lined channel delivering into a 50-ft. diameter inclined shaft connecting with the outer diversion tunnel.

Outlet Works—Outlet works on each side of the river will consist of two separate systems each regulated by a cylinder gate in the bottom of an intake tower.

Construction Program—On the assumption of April 15, 1931 as the date of beginning work the construction progress schedule prepared by the U. S. Bureau of Reclamation covers a period of about 7 years. It calls for completing the four diversion tunnels by Oct. 1, 1933, and the cofferdams by May 1, 1934. The program fixes Dec. 1, 1934 as the date for starting the placing of mass concrete in the dam. By June 15, 1936 progress should have been sufficient to permit the beginning of water storage behind the dam, and by Sept 1, 1936 all features necessary for the generation of power should be ready for service. All of the remainder of the work under schedule, including completion of power house and power plant for six units on each side of the river must be completed within 2,625 days, or 7 years (about May 1, 1938). Failure by the contractor to maintain specified progress will be penalized by exacting liquidated damages at the rate of $3,000 per day.

For the U. S. Bureau of Reclamation the plans and specifications for the Hoover dam were prepared under the direction of Dr. Elwood Mead, commissioner, R. F. Walter chief engineer and J. L. Savage, chief designing engineer.

PLAN AND CROSS-SECTION AT DAMSITE. Major features of project include 730-ft. high dam, four diversion tunnels, spillways, 3-ft. diameter penstock tunnels, U-shaped power plant, outlet works, two cofferdams and intake towers.

Progress of Hoover
YEAR AHEAD

By J. I. BALLARD

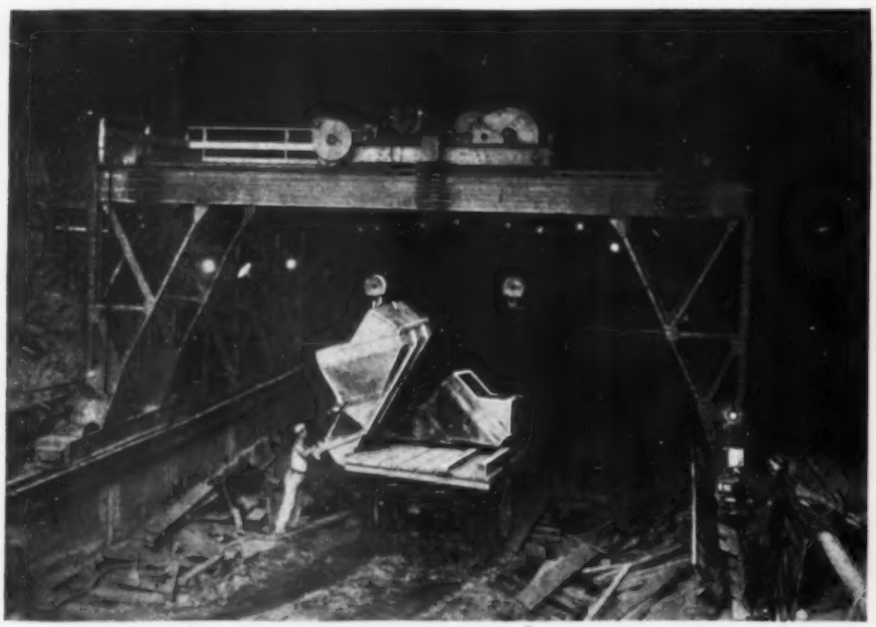
Pacific Coast Editor of Construction Methods

THROUGH the torrid heat of the second summer the Six Companies Inc., are carrying forward the Hoover dam construction program at an accelerated pace. Since March 11, 1931, when Frank Crowe, general superintendent, arrived on the job, transportation facilities have been completed, the aggregate and concrete plants are running smoothly and in the canyon the driving of the four 50-ft. diameter diversion tunnels has been finished and concrete lining is well under way.

In all, after a year and a half, the project is running almost a year ahead of the original schedule and this advance will be assured if the river diversion is completed before the high water season of 1933. Meantime the Bureau of Reclamation has completed the building of Boulder City, Nev., including all modern conveniences for a town of 5,000. Considering the magnitude of the work and the physical difficulties of distance and climate, the accomplishments thus far at Hoover dam are unsurpassed in the history of construction enterprises.

Boulder City—Today Boulder City is a busy town of 4,500 people enjoying all the conveniences of a modern community in a location which eighteen months ago was bare desert. In addition to the 900 buildings which have been erected by various interests, the major construction work consisted of providing 10 mi. of surfaced streets and the same amount of sidewalks, almost 20 mi. of water and sewer lines, a complete water treatment plant and a modern sewage disposal works. Permanent buildings have been erected by the government to house the municipal administration as well as the offices of the Bureau of Reclamation. The Six Companies have erected hundreds of 2 and 3-room residences, 13 dormitories and several large administration buildings, mess hall and shops.

The town is completely equipped with business enterprises of all kinds, churches have been erected and an 8-room elementary school building is under con-



CONCRETE FOR LINING the 56-ft. diameter diversion tunnels is delivered by motor truck in special bottom-dump buckets which are picked up by traveling gantry crane.

SUSPENSION BRIDGE carries motor trucks across river at damsite. Water clarification plant in foreground.

CONSTRUCTION CITY sprouts on Nevada desert. For housing engineering and construction personnel, a modern municipality, Boulder City, is created at site 6 mi. from Boulder Canyon.

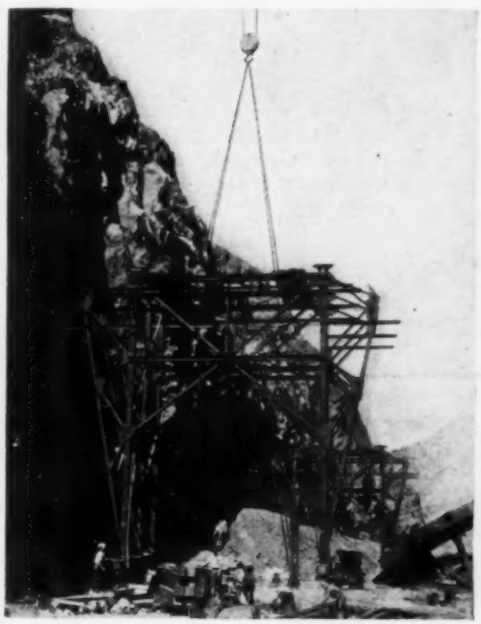
Dam Construction Is OF SCHEDULE

struction by the government. Transportation to Las Vegas is provided by several bus lines, and the town is on a fine surfaced highway which at present extends to the damsite but will eventually cross the dam and extend into Arizona. Landscaping has been done by the government in the public areas and around the public buildings. Many of the residents have improved their own yards with plants procured from the surrounding desert.

Transportation — To provide railroad facilities from existing lines to the site of Boulder City required the building of a branch from the Union Pacific Railroad near Las Vegas 23 mi. to the town site. The highway between the two points was also relocated and improved. These units were completed prior to the commencement of actual work on the main contract.

The extending of these transportation facilities from the site of Boulder City to the canyon involved much more difficult construction. About 10 mi. of railroad line, including 5 tunnels, were built by the government from Boulder City to the canyon rim on the Nevada side. In addition to this line now being operated by the Six Companies Inc., the contractors added almost 26 mi. of their own railroad line extending to the Arizona gravel pit and into the canyon.

The 6-mi. main highway from Boulder City to the canyon was constructed by the government and has been supplemented by many miles of construction road built by the contractor to open up



JUMBO designed by contractors for pouring concrete in arch section of tunnel lining.

AGITATOR-BODY TRUCKS deliver concrete to inclined chute for lining circular diversion tunnels. Note steel wall forms in place in tunnel.

Population of 4,500 is served by waterworks and pumping plant, sewers and paved streets. About 1,000 buildings have been erected, including residences, warehouses, stores and shops.

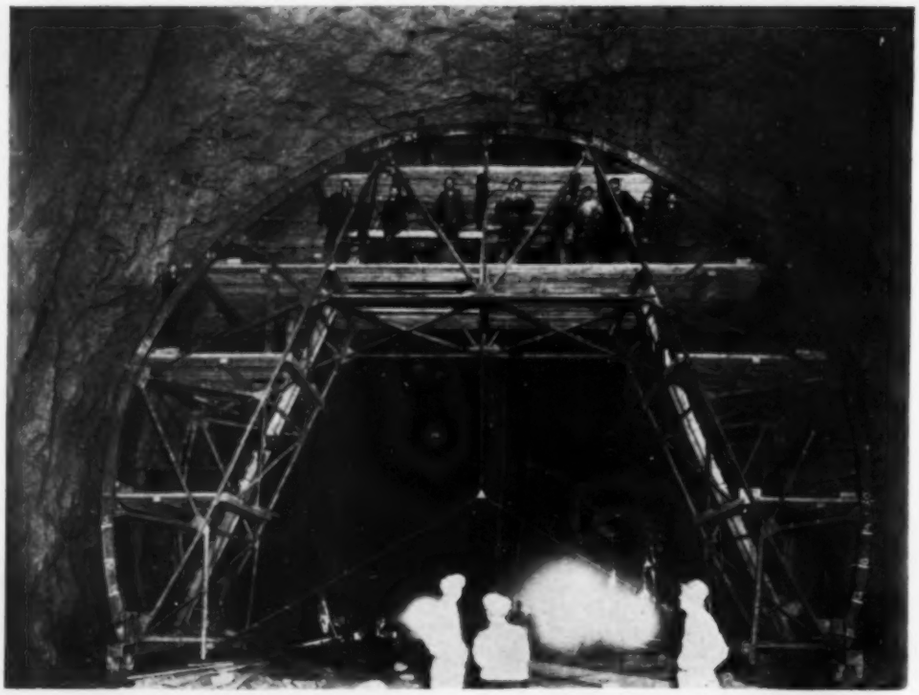
various points of attack. In addition, 50 mi. of construction telephone line have been built and 20 mi. of 2,300-volt power line to serve various units from the central substation.

Housing—Construction forces of the Six Companies Inc., which have numbered more than 3,000 at times, are housed in 172-man dormitories or live with their families in the houses erected by the contractor in Boulder City. The dormitories are equipped with air conditioning systems for cooling in summer and heating in winter. A charge of 10c. a day is made for the dormitory quarters, which includes bedding. The family houses of 2 or 3 rooms rent at a charge estimated to amortize their cost during the construction period.

Supplementing the main facilities in Boulder City a 500-man camp is operated in the canyon about a mile from the site. Housing and feeding equipment provided by the contractor repre-

sents an expenditure of about $140 per man. The boarding house equipment and operation are described on another page of this issue.

Concrete Aggregate — The providing of aggregate for 4,500,000 cu.yd. of concrete to be used in the dam and other structures provided a major problem. According to contract, the aggregate has to be taken from gravel pits on the Arizona side of the river, a distance of about 8 mi. above the site. The plan of operations, resulting from much study of the problems involved, provides for loading the raw gravel at the pit into railroad cars and moving it to a screening plant, located about 2 mi. from the damsite. Here the pit run material is screened into sand and four sizes of aggregate. From the plant it is taken by railroad cars to the concrete plant located in the canyon near the portal of the Nevada diversion tunnels. The features of the gravel pit and screening plant operation



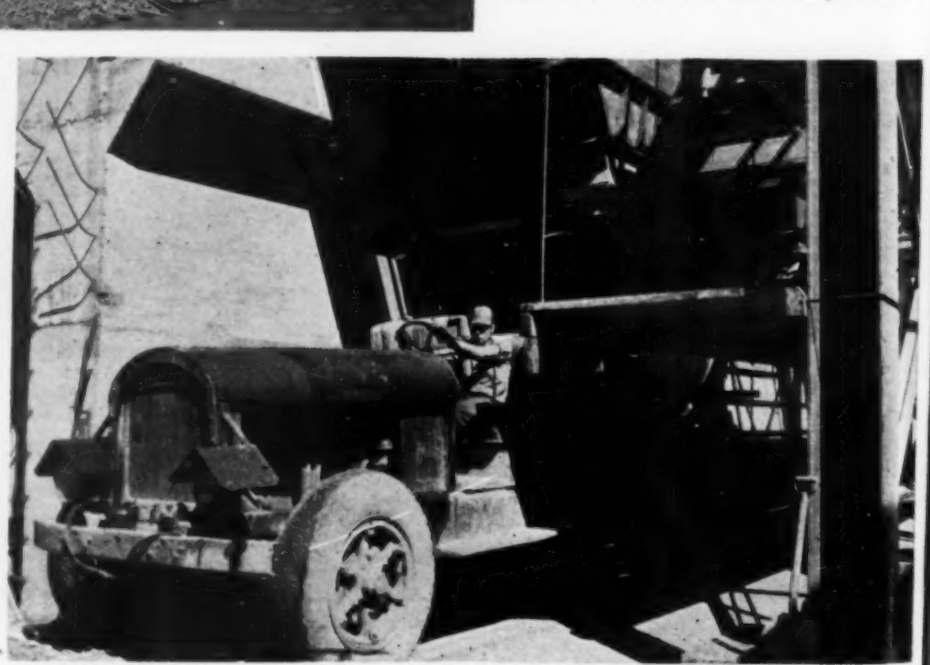
FOR TRIMMING ROCK in 56-ft. diameter diversion tunnels contractors employ steel-frame jumbo with platforms at different levels.

CONCRETE MIXING PLANT *(below)* at river's edge is equipped with four 4-cu.yd. mixers.

extend from the open cut spillways to the outside diversion tunnels on each side of the river for permanent use, there is a large number of smaller diameter bores to be driven to connect the penstock tunnels with the outlet towers and the powerhouse location. Tunneling operations will be under way for some time yet in completing the smaller tunnels which will be used for the ultimate operation of the project.

Tunnel Lining—The placing of a 3-ft. concrete lining in 16,000 ft. of 50-ft. diameter tunnel is a major undertaking and requires equipment designed especially for the job. Lining operations are carried forward in three steps. First,

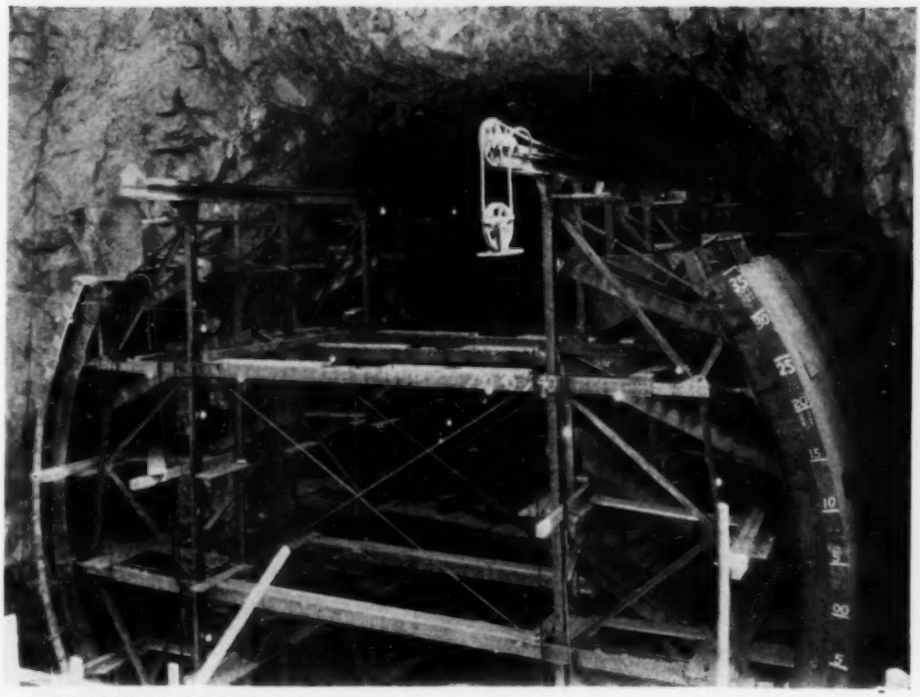
CONCRETE BATCHES *(right)* are dropped into agitator bodies of trucks for delivery to forms.



were described in detail in the July issue of *Construction Methods.*

Diversion Tunnels — River diversion constitutes a major construction feature of the Hoover dam project and requires completion before any major operation can be started on the structure itself. The four 50-ft. diversion tunnels, two on each side of the river, constitute a tunneling job unparalleled in magnitude of operation and unique in the methods employed. The methods used in driving these large bores are described elsewhere in this issue. Excavation work has been practically completed at this time and lining operations are under way.

Completion of the four main diversion tunnels does not end the tunneling work on the project. In addition to the large capacity inclined spillway shafts which



SIDEWALL FORMS *(above)* in place for the 3-ft. thick lining of the diversion tunnels. Side wings are jacked into place and concrete poured through ports by crane.

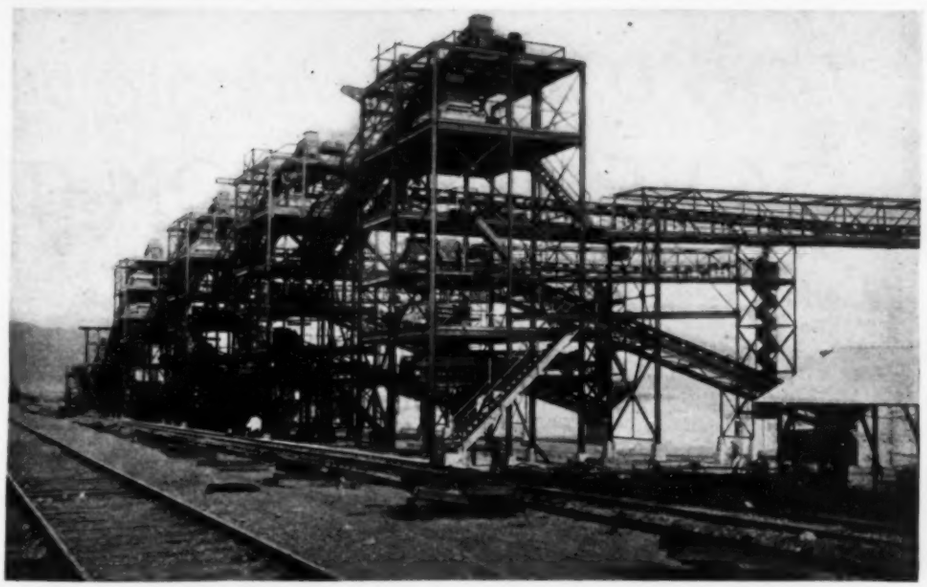
the invert concrete is placed and struck off to line without forms. Second, concrete for the sidewalls is placed behind steel forms up to the last 110 deg. of arc, which constitutes the roof section. Third, the last stage consists of placing the arch concrete by pneumatic methods.

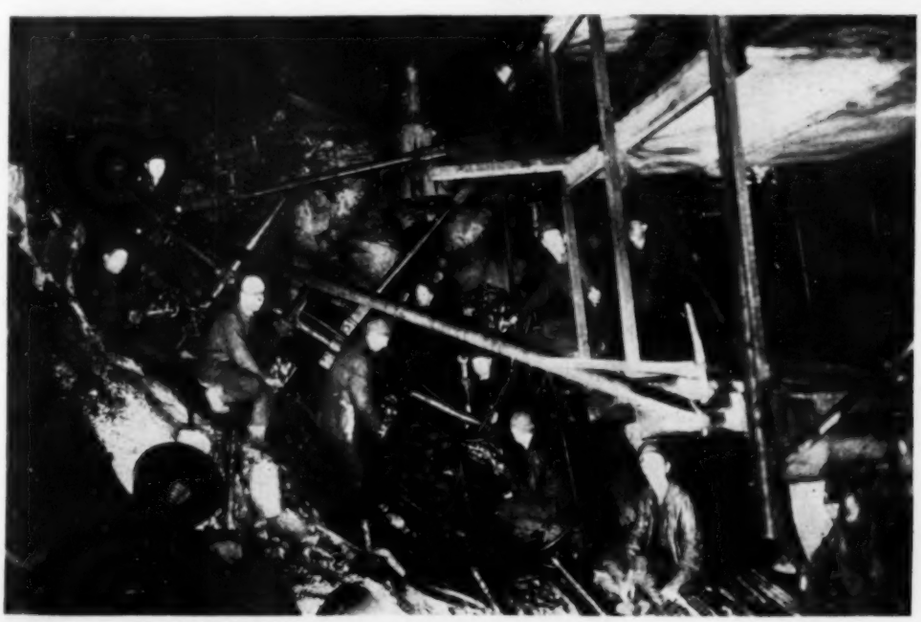
In all cases the equipment to handle forms and concrete is electrically operated. For the invert and sidewalls gantry equipment is used to handle the concrete in the 2-yd. buckets for placement. Concrete is transported from the mixing plant in agitator-body trucks to the point of placement. These trucks operate over a roadway along the canyon wall and across a suspension bridge which is above high water mark. The portals of the eight diversion tunnels are protected by concrete dams over which are ramps built to permit the carrying out of lining operations during high water.

Miscellaneous Operation — Scaling of the canyon walls has been under way for some time, primarily to remove loose and dangerous rock but also to begin excavation for the dam abutments. Work is well advanced on the excavation of thousands of cubic yards of rock from the open-cut spillways on both sides of the canyon. Cableways are being constructed across the canyon at various points to handle material and prepare for the removal of foundation excavation for the dam. Later these cableways will be used to deposit concrete in the structure.

The beginning of actual excavation in the damsite proper will be started as soon as the river flow can be diverted into the tunnels after lining operations

AGGREGATE PLANT *(below)* has present production capacity of 500 tons per hour. Sixty-foot towers are equipped with belts and screens for sizing the material.





DRILLING *(left)* the invert section of one of the diversion tunnels. Steel jumbo on truck carries battery of air drills.

have been completed. Present plans call for diversion of the flow during the low water stage during the coming winter by a temporary diversion dam placed immediately below the upstream portals. The diversion of the river will permit work on the building of the upstream and downstream permanent cofferdams and also would open up the actual damsite for foundation excavation. It is planned to rush construction of the permanent cofferdams during the winter months prior to the high water season of next summer, which would complete the diversion of the river one year ahead of actual contract schedule. The actual damsite would then be open for uninterrupted work on the foundation of the dam.

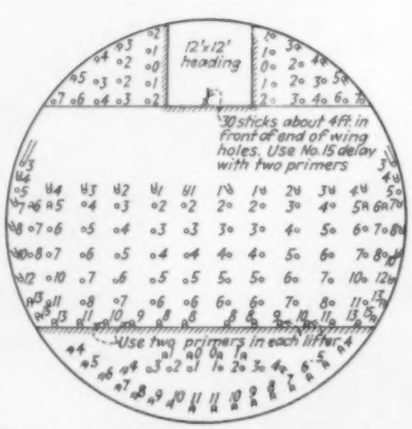
Union Pacific Photo

ENLARGING TUNNEL SECTION to full 56-ft. diameter by drilling face from jumbo on motor truck.

Thirty Drills on Truck-Mounted Jumbo Bore

56-FT. DIVERSION TUNNELS

IMAGINE yourself at the face in one of the 56-ft. diameter diversion tunnels (50-ft. diameter inside finished concrete lining) for the Hoover dam project, watching bench-enlargement operations in full swing. You would be standing on the remaining invert section, about 45 ft. in width and 15 ft. in depth, with the roof of the tunnel about 35 ft. overhead. There is no timbering or other support, and the noise of the 30 drills on the jumbo reverberates in the cavernous bore. Under bright floodlights a crew of 45 men swarms over a drilling jumbo of structural steel mounted on a motor truck which is backed up against the face. This piece of equipment constitutes a major development in tunneling practice made by the Six Companies Inc., San Francisco, contractors for the Hoover dam project, and has contributed much to the progress made in driving the diversion tunnels which constitutes the most important phase of construction to date.

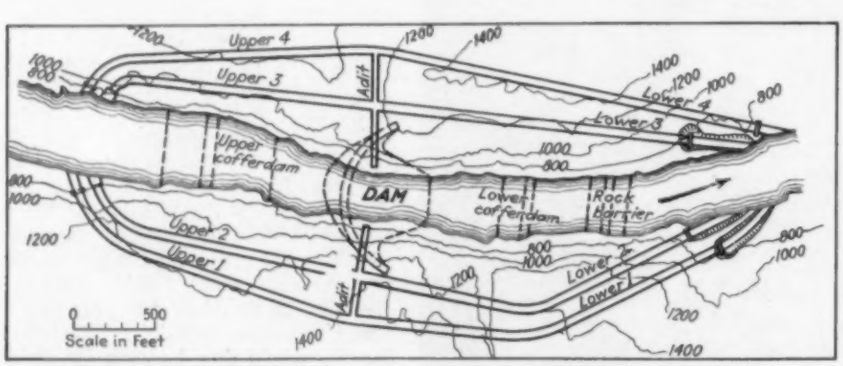

12'x12' heading
30 sticks about 4 ft. in front of end of wing holes. Use No. 15 delay with two primers
Use two primers in each lifter

DRILLING DIAGRAM shows location of holes and firing sequence for removal of top heading wings, bench and invert.

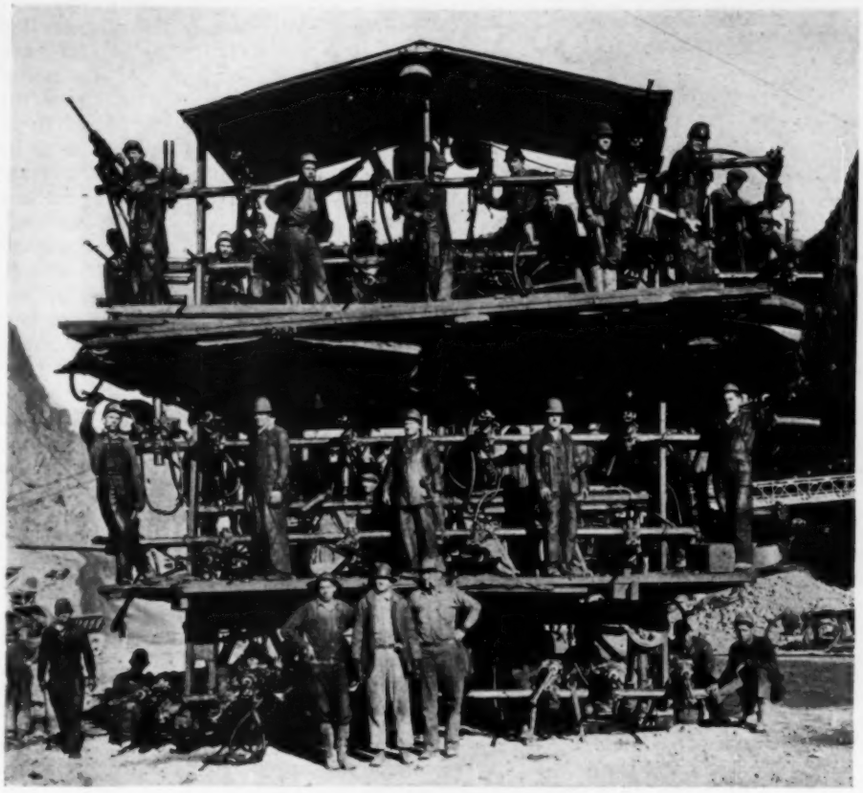
Drill Jumbo — An inspection of the jumbo at closer range discloses five horizontal bars carrying six drills each in addition to providing working platforms and the necessary connections for air and water lines. The rear end of the truck, nearest the face, is jacked up while drilling is in progress, to steady the drills and relieve the truck of the vibration. Wedges have been placed against the front wheels to keep them in position. The 30 Ingersoll-Rand drills are working on 55 holes for the first half of the round after which the truck will be moved with a quick shift, requiring only about 15 min. to the other side of the heading to complete a drilling round in about 2½ hr.

Starting steel for the top row of machines is often 12 ft. long because of irregularities and slope of the face. Maximum length of steel for the rounds, which have averaged 16 ft. in depth, was originally 20 ft. but was later increased to 23 ft. During maximum tunnel driving operations 97 tons of Crucible Steel Co. drill steel was required in circulation to keep all the drills busy. The loss of steel has averaged 0.32 lb. per cubic yard of rock including loss, breakage and wear.

Watching operations closer you would



BOTH ADITS AND PORTALS serve as points of attack on excavation for four diversion tunnels in canyon walls.



JUMBO, in form of welded steel frame mounted on motor truck, carries 30 drills on five bars. Two setups drill 110 holes for bench enlargement.

observe that the rock, which is an andesitic tuff breccia of volcanic origin, appears hard but drills quite easily. Further, a glance at the walls and roof indicates that it breaks well to line, is dry and without faults or seams. A query confirms the fact that it also shatters well and is handled without further breaking by the shovel during mucking operations.

Now, one of the crew on the upper level of the jumbo is lowering a red light globe on an extension cord and the crews below are retreating under the plank platforms while steel is changed or the holes blown above. This is a safety precaution observed in the operation of the jumbo. Also, it is noted that all of the crew, as well as all of the tunnel workers, are wearing miners' hard hats as a precaution against falling rock. With the roof 35 ft. overhead even a fragment as big as a walnut might be serious.

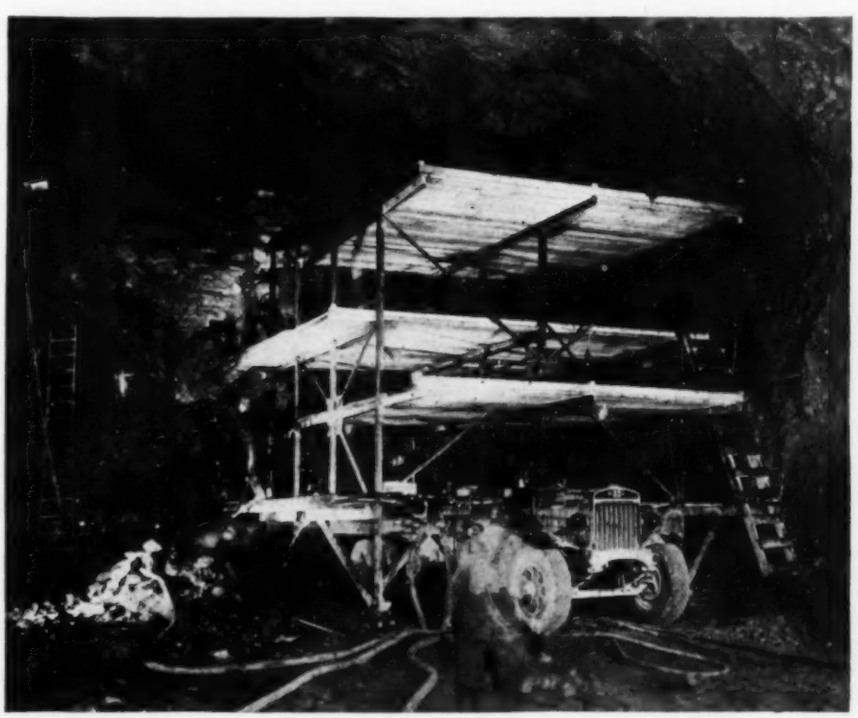
Leaving the jumbo operations for a more general look at the heading it can be seen that the round drilled from the jumbo advances a bench 22 ft. high and 56 ft. wide on the maximum diameter. This outside dimension provides for a 3-ft. thickness of concrete lining and leaves a 50-ft. diam. finished tunnel. Above this major bench face can be seen the top heading 12 ft. high at center consisting of the 12x12-ft. center heading which has been completed from portal to portal and the two sector-shaped wing sections. These two wings are being carried forward simultaneously with the main bench but about 25 ft. in advance. On this upper level drill crews are at work with columns carrying two machines drilling the fifteen holes for each wing.

Ventilation—The freshness of the air at the face in distinctly noticeable, and, upon questioning, you learn that a blower in the 12x12-ft. top heading at the adit near the center of the tunnel is forcing air through the heading and down over the face. To assist in completing this ventilation system a blower farther back in the main tunnel is keeping the air on the move out of the portal. A later trip to the face when mucking operations are in progress and a double line of trucks rolling in and out of the tunnel, finds air conditions as satisfactory and you are informed that tests by instruments indicate air conditions are better than those in the average vehicular tunnel.

Glancing again at the work on the jumbo, you will see the drill holes being loaded from the same piece of equipment, always leaving at least one empty hole between loading and drilling. The round of 120 holes (including the 30 wing holes) is loaded with about 2,000 lb. of 40 per cent explosive and the 16-ft. round brings down a total of 1,050 cu.yd. of rock from the bench and the wings. The layout of holes and the sequence of firing are shown in the accompanying diagram. The shooting is the last operation of the drilling crew on leaving the heading. On completion of the round, the jumbo is driven out of the tunnel and into the adjacent heading where work is started on another round. These operations are carried out with four jumbos drilling the eight headings and one jumbo in reserve.

Mucking—Returning to the face after the shot, you will see the clearing up operations actively in progress. Up on the upper bench a 30-hp. Caterpillar tractor is pushing the rock from the wings down over the face of the bench into the main muck pile. The top center heading was cleared by 30 sticks of powder and exploded with the least delay. With this opening blasted out the tractor, nick-named the "Doodle-bug," which had been waiting farther back in the heading, moves forward and clears off the bench, after which the drill crews begin immediately on the wing holes.

Meantime, a 60-hp. tractor is clearing up the fragments on the floor and a



PLATFORMS on jumbo carriage enable drill crew of 45 men to work simultaneously at different levels.

TRIMMING AND SCALING of rock in 56-ft. bore is done from a movable steel frame prior to placing the 3-ft. thick concrete lining.

Marion electric shovel is moving into position from its location about 300 ft. back from the face. This electric shovel of normal 2¼-yd. size has been equipped with a 3½-yd. bucket and has proved a most efficient piece of equipment in this difficult work, according to the Six Companies. A shovel is provided for each heading.

Mucking is soon under way and the trucks are rolling in and out. Clearing up has consumed about 1 hr.; from 7 to 9 hr. later the mucking will have been completed, making an average cycle of from 11 to 13 hr. and a general routine of two rounds in 24 hr. The mucking crew is unusually small for the volume of 1,050 yd. of rock for each round and consists of a shovel runner, oiler, helper and three or four laborers to assist in clearing up. As the work nears completion the tractor assists in clearing up the last of the loose material. At the end the shovel loosens and brings down all the shattered material from the face to make ready for the next drilling round.

Just before the next round starts the outline of the face will be painted, under the direction of government engineers, to indicate the side line and center line for the spotting of the jumbo for the next round.

Progress Records—In this concentrated inspection of a 12-hr. cycle you have watched the major phase of the tunnel driving work and the advancing of the bench (1,844 sq.ft.) an average of 16 ft. per round. This type of work was at its height during January when the eight headings were advanced 6,747 ft. and 446,818 cu.yd. of rock were excavated. The best day's record for the eight headings was made on Jan. 20 when 256 ft. of progress was made involving the removal of 16,731 cu.yd. of rock. The best consecutive week's record for a single heading was made during the first seven days of February when the 21 shifts advanced a heading 246 ft. in fourteen rounds or an average of 17.57 ft. per round. During a two weeks' period the latter part of January the average tunnel excavation amounted to about 15,000 cu.yd. for every 24 hr. Some of the figures of footing progress and yardage removed for the individual headings are shown in the accompanying tables.

Having concluded the inspection of bench enlargement operations, it is interesting to inspect some of the activity at the portals.

Compressor Plants—One of the three main compressor plants is located at the downstream portals on the Nevada side, the other being at the adit and at the upstream portals on the same side of the river. The combined capacity of the Ingersoll-Rand compressors at all three plants totals 16,000 cu.ft. made up in units of 1,000- and 2,000-cu.ft. standard machines driven by synchronous motors. The downstream portal plant has the largest capacity, totaling 8,000 cu.ft., and the equipment includes the usual provision for air screening at intake and water cooling. From these compressor plants air is piped into the tunnel with 4- or 6-in. diam. lines. In all three installations a suspension bridge carries the

MOTOR TRUCKS, with special steel dump bodies of from 6- to 14-cu.yd. capacity, remove tunnel muck. Note hoods protecting drivers and motors.

ELECTRIC SHOVEL, with 3½-yd. bucket, loads tunnel bench excavation in motor trucks for removal to dumps. Invert section 14 ft. deep still remains to be excavated.

air lines across the river and into the headings on the Arizona side.

Close by are the emergency truck shop and greasing racks. Here the trucks receive such first aid as may be necessary in keeping them going until a time when more complete servicing is required and they are removed to the main shops at Boulder City. According to program, a regular periodic servicing of the truck fleet was called for but the speed of operations and the demand for all available equipment resulted in the trucks receiving little or no attention, aside from the driver's oiling, except in case of breakdown.

During major operations, the truck fleet included about 60 Internationals of various sizes, sixteen Morelands with 6- to 10-cu.yd. bodies, 24 Whites (Wood hoists) with 8-yd. bodies, and five Macks (Heil hoists) with 14-yd. bodies. The truck bodies are of ⅜-in. steel plates with reinforced sliding plates on bottom and special hoods over the driver's head for protection and were built by the Consolidated Steel Co., Los Angeles. Both pneumatic and solid tires are in evidence on rear wheels, the front tires being exclusively pneumatic.

Following by eye the line of loaded trucks leaving the downstream tunnel portals they are seen to haul a distance of about one mile, mostly up grades of 10 and 12 per cent to disposal areas high on the canyon walls as the specifications prohibit dumping at lower levels.

Invert Removal—A trip into the heading of the adjacent tunnel permits inspection of the wall scaling and invert removal operations which constitute the other major tunnel driving process. The invert left after the main bench enlargement is the bottom sector about 15 ft. deep at the center line with a face of 720 sq.ft. which is removed in rounds averaging about 20 ft. This invert section is drilled by a truck mounted jumbo not unsimilar to the one used for the bench, in fact, the invert jumbos were rebuilt following completion of bench excavation. The principal difference is the shape of the lower bar which is curved to follow the bottom line of the tunnel and mounts twelve drills. A shorter horizontal bar carries six machines and the jumbo is complete with equipment for connecting with air and water lines. A special feature of this jumbo is the hinged arrangement of the lower bar which permits the sides to be folded back against the truck during moving.

This jumbo is spotted on the center line and drills 28 holes at one set-up to complete the invert round. Drilling time is about 1½ hr., and the round is loaded with 1,000 lb. of 40 per cent explosive which loosens 320 cu.yd. of rock. The sequence of operation is similar to bench enlargement, the mucking time averaging about 3 hr. Shovel operation is slowed up by the fact that the shovel must make a swing of 180 deg. with the trucks re-

TUNNEL DRIVING CLINIC (Left to right) A. H. AYERS, chief engineer; FLOYD HUNTINGTON, tunnel superintendent; JACK LAMEY, tunnel foreman, all of Six Companies Inc., confer with BILL ELLIS, resident explosives expert of Hercules Powder Co.

TABLE I — TUNNEL EXCAVATION PER MONTH IN CUBIC YARDS

Heading	Prior to November	November	December	January	February
Lower 1	.....	.....	23,469	59,403	32,300
Lower 2	.....	32,620	39,270	56,270	6,525
Lower 3	.....	31,330	41,890	56,610	7,385
Lower 4	.....	26,760	44,080	54,030	7,425
Upper 1	.....	.....	3,025	56,670	18,363
Upper 2	.....	10,090	36,890	58,290	11,365
Upper 3	.....	9,300	33,450	51,745	11,090
Upper 4	.....	12,355	29,740	53,800	28,235
Total	137,747	122,455	251,814	446,818	122,688

Note: Top headings completed during December; January figures include only bench enlargement. February figures include 39,660 cu.yd. of invert excavation.

TABLE II — PROGRESS OF BENCH ENLARGEMENT PER MONTH IN FEET

Heading	Prior to November	November	December	January	February
Lower 1	...	.....	389	886	499
Lower 2	...	495	609	885	81(2)
Lower 3	...	458	637	832	....(1)
Lower 4	...	394	677	841	30
Upper 1	...	.....	40	824	175
Upper 2	...	150	570	911	59(2)
Upper 3	...	132	504	780	....(1)
Upper 4	...	180	418	788	414
Total	724	1,809	3,844	6,747	1,258

Note: (1) Tunnel No. 3 holed through Jan. 30.
(2) Tunnel No. 2 holed through Feb. 4.

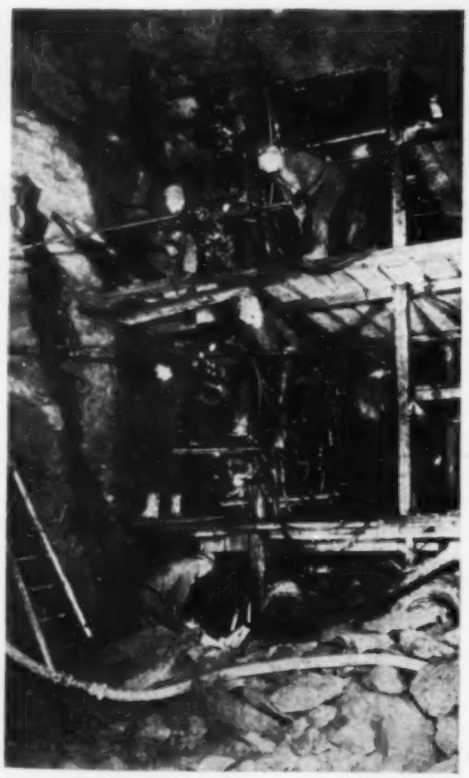
maining on the portal side. To permit swing of the cab, about 2 ft. of loose material is allowed to remain on the floor to be removed with the final clearing prior to lining.

Scaling—Ahead several hundred feet in the tunnel, in the section ahead of the invert operations, can be seen the scaling jumbo which is a structural steel form of 50-ft. diameter down to the invert. The rails on which this jumbo moves are set to line and grade and as it is moved ahead it permits quick and accurate measurement of clearance and permits blockholing of projections. As this jumbo moves ahead and trims the roof and walls with such minor shooting as is necessary, the material is allowed to remain and is removed with the invert operations.

With the removal of the invert the tunnel has been completely excavated and is ready for final cleaning of the bottom and beginning of the lining operations. Concrete lining operations are just beginning and have not been worked out in fullest detail but in general will consist of three steps: First, the invert section will be placed by gantry crane equipment after which the side walls will be placed behind steel forms using gantry equipment and bucket and, lastly, the arch will be placed pneumatically.

Having visited the two major tunnel driving operations and inspected the major pieces of equipment in operation, there remains only the requirement of sketching the program of attack which made possible the speed obtained in these major tunnel operations. Because the progress on the project as a whole depended upon completion of the diversion tunnels, it was essential to get the tunnel operations under way as quickly as possible and to open up the faces without delay.

Tunneling Plan—Within six weeks after the forces of the Six Companies arrived on the site, work was under way in opening up adits near the center of the tunnel line, on the precipitous canyon walls. These adits provided two additional working faces for each of the four tunnels. By means of boat and barge equipment on the river a foothold was soon blasted in the canyon walls suitable for compressor plants and equipment, a



DRILLING FACE of bench section from truck-mounted steel frame jumbo.

suspension footbridge was thrown across the river and temporary equipment was available for starting the adits. Each adit was driven to 10x8-ft. section at right angles to the canyon wall, using Conway mucking machines and storage battery locomotives as soon as electric power became available. Intersecting the first tunnel line 370 ft. in from the canyon wall the adits were continued until they reached the inside tunnel line at a distance of 750 ft. With the opening up of these eight faces the top 12x12-ft. headings for the main tunnels were turned at once. In the meantime, some work had been started in opening up the faces at the portals of the main tunnels but this work was slower and the majority of the footage in the top headings was driven from the adit end. These top center headings were useful in determining the character of the rock and its breakage in addition to opening up the tunnel lines for ventilation during major operations.

The top headings were driven to a 12x12-ft. section by standard methods with rail-mounted drill carriages. Rounds of about 12 ft. were pulled and in general heading driving procedure was in accordance with usual practice and did not develop any features of unusual interest.

The enlarging from the top heading, as previously described, constituted the typical procedure although experiments were tried with other types of driving. In one case a portal was opened up and carried forward with a top bench section before the heading had been holed through. But this was discontinued and changed to standard procedure when the top heading had been completed. In another case, ring drilling was tried from the top heading but the handling of breakage was difficult and this was not continued. Thus, practically all of the enlargement was done from the portal end, using the method described in the foregoing.

Personnel—Operations of the Six Companies Inc., under the personal direction of Frank T. Crowe, general superintendent, are under the supervision of the board of directors of the organization, with Charles H. Shea as resident director. A. H. Ayers is chief engineer, and Bernard Williams, assistant superintendent, is in charge of work in the canyon. Floyd Huntington is tunnel superintendent with Jack Lamey, C. T. Hargrove, Paul Guinn, and Tom Regan as assistants. Mucking operations are supervised by B. A. Peters, Leigh Cairns, Pete Hansen and Frank Bryant.

Stanley Francom is resident representative of the Ingersoll-Rand Company which supplied all air and drilling equipment. Bill Ellis is resident explosives expert for the Hercules Powder Company.

Supervision of the project by the Bureau of Reclamation is in direct charge of Walker R. Young, construction engineer, reporting to R. F. Walter, chief engineer, Denver office. John C. Page is office engineer, Ralph Lowry field engineer, and Paul Jones is field inspector on tunneling operations.

Union Pacific Photo

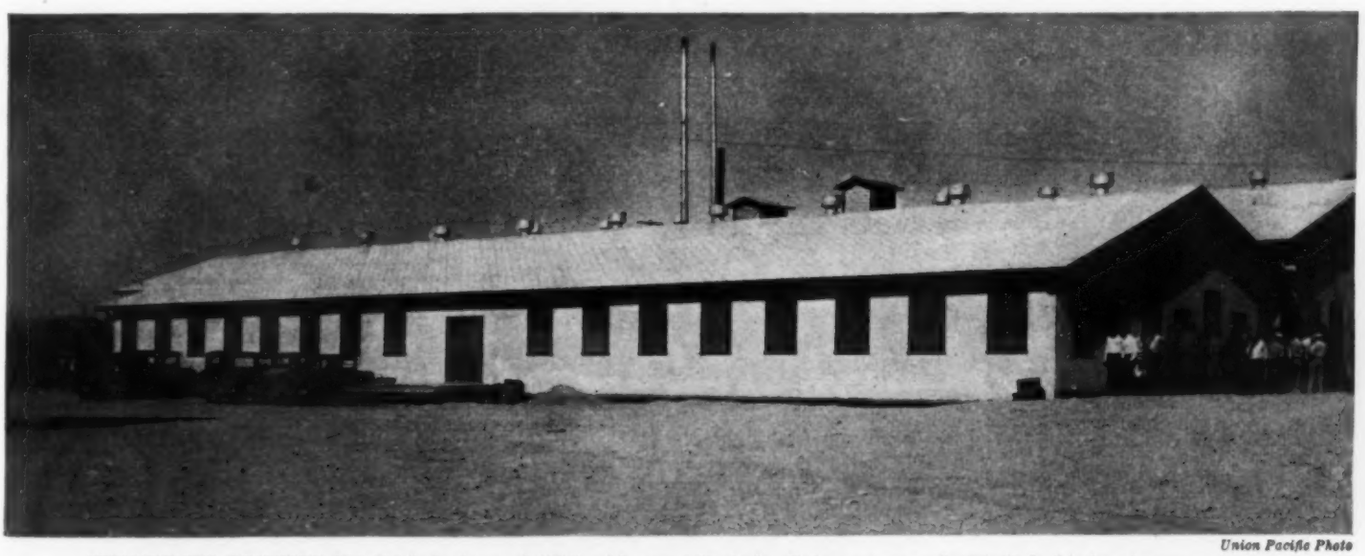
MESS HALL at Boulder City seats 1,200 at eight-man tables and is equipped with ventilating system.

Feeding the HOOVER DAM Army

JOIN the rush for dinner in the Six Companies' 1,200-man mess hall and get first-hand information on what the Hoover dam worker is getting to eat. Pull up your chair—not a bench—to an 8-man table and begin. If you want to start with soup, there it is. Next, you may load your plate, according to the accepted custom, with either of two kinds of meat, potatoes, at least two other vegetables, salad and relishes. To drink you may have your choice of fresh milk, buttermilk, coffee or water—and, in the summer, iced tea or lemonade—at any meal. For dessert—and there seems to be no hesitating at this point—there is pie, pudding or cake. At all twelve meals during each 24 hr. the same abundance of quantity and high standard of quality prevail. Under the direction of the Six Companies Inc., contractors for building Hoover dam, the Anderson Bros. Supply Co., of Los Angeles, is keeping the Hoover dam army well fed. The charge is 50c. per meal.

Mess Hall—The combination mess hall and kitchen is in the form of an "H" with the two outside dining wings seating 600 each, and the central portion containing kitchen and storage rooms. The two parallel dining rooms are each 142 ft. long by 40 ft. wide and the kitchen occupies a space of 195x55 ft. The building cost almost $50,000 and the equipment in excess of that figure. The building is of frame construction with stucco exterior, with roof supported on steel trusses. Dozens of large electric fans aid ventilation, and radios in the dining rooms furnish music or the latest news.

Kitchen—The main kitchen provides for either electric, oil or steam cooking.

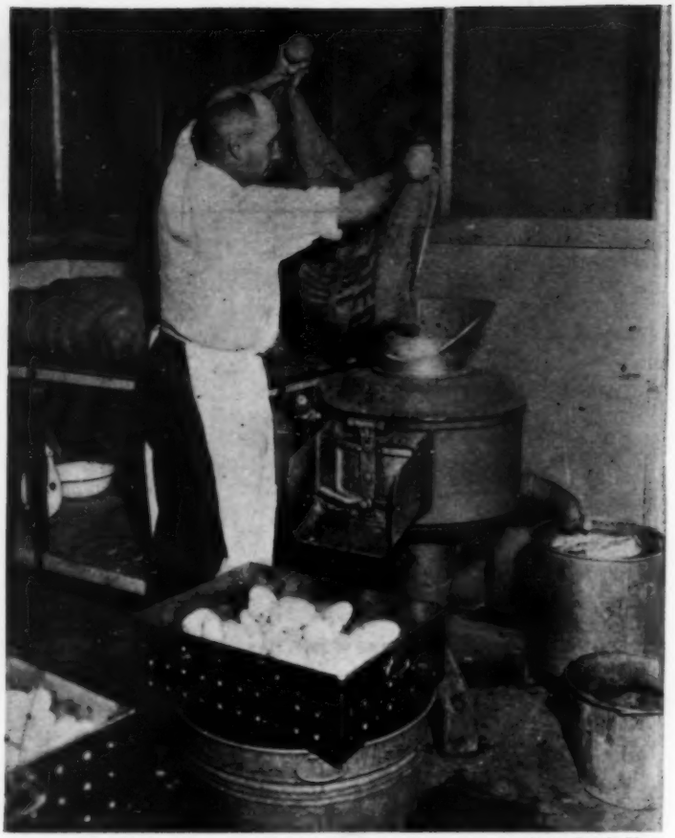


Union Pacific Photo

STRUCTURE COSTING $50,000 is in form of "H," with two 142x40-ft. dining rooms and 195x55-ft. kitchen between them.

Union Pacific Photo

BREAD for 2,000 men daily is cut into slices by machine in kitchen.



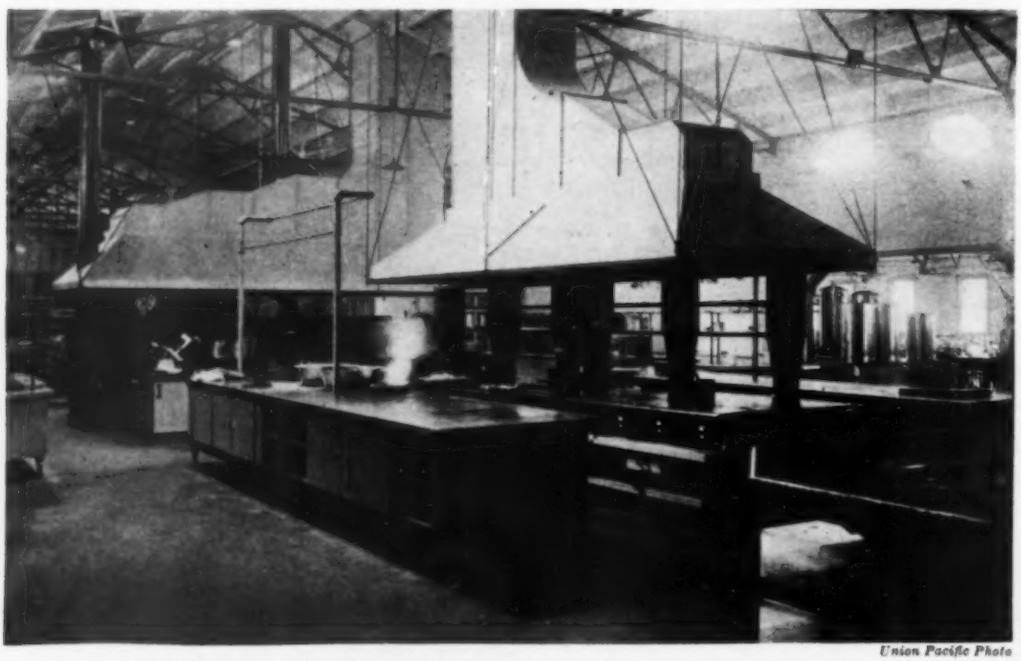
Union Pacific Photo

POTATOES are peeled mechanically, a sackful at a time.

All kitchenware is aluminum and all other equipment is either metal or hardwood. Dishwashing machinery of the latest design is used. In addition to the main cooking room, there are smaller rooms used for meat cutting, baking and preparation of vegetables.

At the rear of the kitchen there is equipment for unloading trucks and freight cars directly to storage rooms. Meat can be unloaded by overhead tracks into refrigerated rooms and the basement provides storage for non-perishables. Refrigeration for the numerous cold-storage rooms is provided by a 20-ton Parker ice plant which provides refrigeration, ice and circulating ice water to the mess hall. The arrangement of the supply rooms and kitchens provides for efficient handling of food materials, the layout being designed for handling of foods from unloading to cooking with the least inconvenience.

Food—Only the highest grade of food material is used and this is purchased directly by carload lots from packing establishments. Much of the meat is delivered from Reno in refrigerated truckloads packed in dry ice and un-



Union Pacific Photo

KITCHEN is equipped with electric and oil-burning ranges and steam tables.

Union Pacific Photo

WAITERS in white uniforms handle mess-hall service.

loaded immediately into the refrigeration room. The canned goods and bulk groceries arrive by freight carloads directly from producers and are stored in the basement. Fresh vegetables and fruits are bought in corresponding quantities and handled with the same care.

Milk and the dairy supplies were a particular problem, and the solution was provided by Anderson Bros., purchasing and equipping with modern dairy facilities a nearby ranch from which dairy products are taken by ice-cooled trucks to Boulder City.

Quantities — With the kitchen equipment and the large staff of experienced cooks meals are prepared without noticeable confusion. Daily the requirements for meat equal 1½ to 2 steers or the equivalent, and the use of about 4,000 fresh eggs. The consumption of butter is about 100 lb. per day and more than 7,000 hotcakes are the requirements for the usual morning's meal. In addition, there are the bakery requirements of hundreds of dozens of cookies, rolls and the bread for 3,000 men.

A special feature of the boarding program is the cafeteria style of providing lunches for the men working in the canyon several miles from Boulder City. These crews constitute a majority of the force and lunches are required for three shifts. Instead of the usual procedure of handing out prepared lunch boxes with the usual difficulty in satisfying individual tastes, the present plan provides a large counter equipped with various kinds of sandwiches, fruits, pies, cakes and food of other kinds from which the men can pick their own lunches in accordance with their tastes and requirements of quantity.

The kitchen and dining room crews are thoroughly experienced in this type of work and many have been with Anderson Bros. for years. Waiters always appear in clean white uniforms and all laundry work is done in a completely equipped steam laundry nearby.

The Anderson brothers, Harold and William, have been in this business for 20 years. Harold was in charge of feeding and housing shipyard crews on the east coast during the War. For years they have maintained their separate commissary organizations, and a territorial agreement, for construction crews and other field forces, including movies on location in the western states. The size of the Hoover dam job resulted in a combination of forces and they were awarded the contract by the Six Companies Inc. to supervise feeding. Harold Anderson is now a resident of Boulder City and personally directs the work.

Menu

Christmas Dinner at Boulder City

❖

Fresh Oyster Soup

Hearts of Celery · Green Olives
Waldorf Salad · Whipped Cream

Roast Young Turkey · Oyster Dressing · Cranberry Sauce

Baked Virginia Ham
Raisin Sauce

Candied Yams · Mashed Potatoes · French Peas

Parkerhouse Rolls

English Plum Pudding · Brandy Sauce · Hot Mince Pie
Fruit Cake

Assorted Fresh Fruits · Mixed Candies · Mixed Nuts

Fresh Milk · Buttermilk · Hot Chocolate · Coffee

Union Pacific Photo

PLENTY of good food going down fast.

Boulder Project Seen as GREAT SOCIAL ENTERPRISE

No Signs of Depression at Hoover Dam, Where 3,000 Workers Are Busy Night and Day

By Henry J. Kaiser

Chairman, Executive Committee, Six Companies Inc.

HENRY J. KAISER

PUBLIC works have been a function of government for centuries and have been so designated by the great exponents of political theory. Often such works have been monuments to the selfishness and greed of politically-minded men; more often, however, they have given enduring evidence of the courage and foresight of real statesmen. Witness the building of the Panama Canal, through faith in leadership.

In the Hoover dam and all the allied works which are included in the project the builders of this nation have entered upon their second great construction, an enterprise which private initiative could not have accomplished. The harnessing of the Colorado River will be a lasting memorial to the Federal authorities who ordained it.

A Social Enterprise—The Hoover dam, as a project, is so vast in its conception and is subject to so many varied and complex social factors and influences that it may well be called a social enterprise. In a definite sense society is building it. It could never have been undertaken without the extensive cooperation of economic and governmental organization.

The Hoover dam is an example of a government enterprise that has two characteristics of singular importance. The first is that the execution of the plan was put into the hands of private enterprise, with the full understanding that, other things being equal, individual initiative and responsibility have been a great force in the economic development of this nation. In other ages a government would have executed such a work by autocratic compulsion with forced labor wrung from a group living close to the margin of subsistence. But American democracy has always recognized the principle that individual enterprise and a reasonable degree of competition have made for progress. The idea is inalienably linked with the principle of liberty—freedom from control.

The second striking feature is the fact that the government, in undertaking this truly public work, has made an investment. Not only will all of the money advanced be repaid within 50 years but a major portion of it will bear interest at approximately 4 per cent. In addition to that, there is a reasonable expectancy, based upon firm contracts, that the government will actually realize a profit of $66,000,000 in about 40 years. Furthermore, Arizona and Nevada each will receive in excess of $31,000,000 in the same period. When one considers the effort which is now being expended upon discovering sources of revenue which will not be a burden upon the people this feature is of outstanding consequence, since the entire program will be completed without recourse to taxation.

In Terms of Jobs—An observer of the Hoover dam activities is struck by the fact that business depression has not penetrated into that region. Nearly 3,000 men are regularly employed and receive more than $15,000 a day for their labor.

A reasonable estimate of the activity created in the main industries which are furnishing equipment, materials and sup-

A MODERN MUNICIPALITY, Boulder City, has been built in the Nevada desert to house a population of 5,000 Hoover dam workers and their families.

plies indicates the equivalent of a full year's employment for 33,300 men by virtue of the construction contracts. If the estimate is extended to include the activities of the Bureau of Reclamation and of the Metropolitan Water District of Southern California, which are integral parts of the control and utilization of the Colorado River, the grand total will approximate the equivalent of regular employment for 238,600 operatives for an entire year.

Furthermore, there is here a stirring demonstration of the cooperation of three major units of effort: First, the Federal Government, vitalizing the venture with authorization and policy. Second, the Reclamation Bureau, a department of that government, executing the plans and specifications, not only with scientific skill and efficiency but with a speed never before witnessed in a public or private enterprise. Third, six individual private contracting firms, each one retaining its identity and its corporate personality and at the same time combining resources under a single direction and control to execute this enormous task.

Features of Project—The dam will be 730 ft. high, nearly twice the height of any dam yet completed. It will be 650 ft. thick at the base. This structure and the reservoir are estimated to cost $70,600,000.

The All-American canal, which will carry the stored waters to irrigators in Imperial Valley, will be 200 ft. wide,

At the annual convention of the Associated General Contractors of America early this year Henry J. Kaiser, contractor, of Oakland, Calif., and chairman of the Executive Committee of Six Companies Inc., described the work of building the Hoover dam. His address is reproduced, in part, herewith.

22 ft. deep and carry 15,000 cu.ft. of water per second. This canal will pass through a wind-swept ridge of shifting sand where the excavation will be more than 200 ft. deep. This will cost $38,500,000.

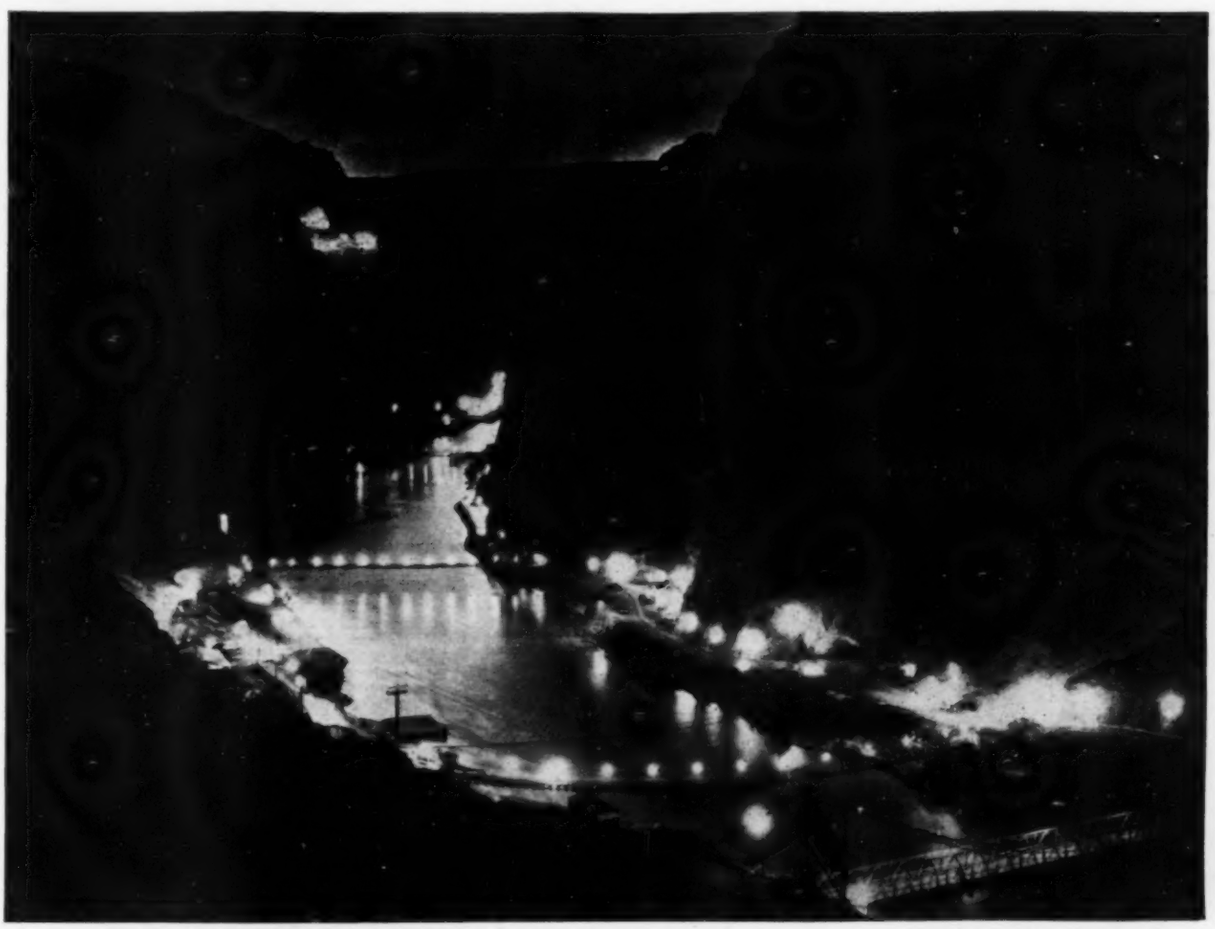
The aqueduct that is to carry water to Southern California will be more than 200 mi. long and the water will be lifted 1,200 ft. in order to cross the Sierra Divide. This will cost about $222,000,000.

The lake above the dam will be 115 mi. in length, 582 ft. deep and will hold 30,500,000 acre-ft. of water, or enough to cover the State of Connecticut to a depth of 10 ft. It will be the largest artificial reservoir in the world, more than eleven times the capacity of Elephant Butte reservoir in New Mexico and twelve times that of the Assuan in Egypt. It could store the entire flow of the Colorado River, if necessary, for three years without a drop of water passing the dam, or sufficient water to supply San Francisco at its present rate of consumption for 560 years without any replenishment to the reservoir.

The installed equipment will be housed in a plant one-eighth mile long in the downstream toe of the dam and will develop about 1,200,000 hp., depending upon the requirements of the purchasers of the power. The Hoover dam will make 663,000 firm or constant horsepower available at all times and will produce an income to the United States Government of about $7,000,000 per year. In contrast, Niagara now develops 557,500 hp.

There are a number of extraordinary comparisons which indicate the size and magnitude of this project. The dam is more than one-eighth of a mile high and two city blocks thick at the base. It will contain more concrete than all other dams of the Bureau of Reclamation put together—enough to pave a standard highway 20 ft. wide from San Francisco to Chicago. This mass will have to be poured at a rate which would cover the average city block 18 ft. deep every week. If the whole were poured into a monolith it would be 2,100 ft. high and cover a solid city block.

The cooling system embedded in the



NIGHT AND DAY work in Boulder Canyon continues twenty-four hours a day, seven days a week. An effective system of illumination facilitates operations along Colorado River.

dam to absorb the heat of setting concrete is equivalent to 152 mi. of 2-inch pipe.

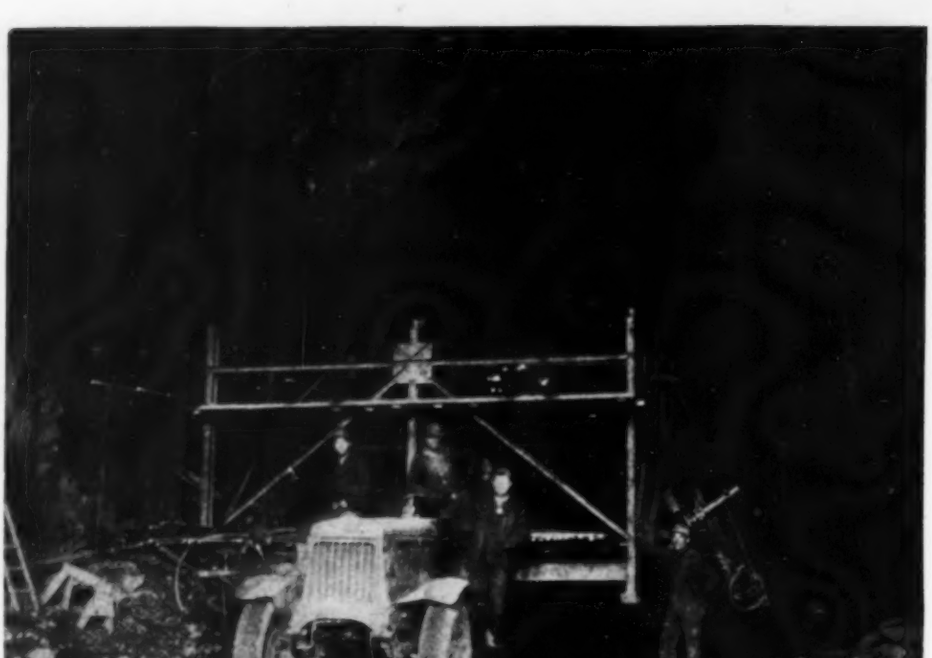
The excavation necessary is approximately equivalent to taking a whole city block in area to a depth of 1,700 ft.

The amount of steel roughly equals the tonnage that was necessary in building the tallest structure in the world, the Empire State Building.

Preliminary Construction — The first three years of work and the first $25,000,000 of expense are for items preliminary to the dam construction proper. The dam is located in the steep Colorado River Canyon, the walls of which are approximately 350 ft. apart and nearly perpendicular for 1,000 ft.

In order to divert the river, it is necessary to construct four tunnels of 50-ft. net diameter (inside concrete linings), each more than three-quarters of a mile long. After temporary diversion dams, massive structures, are completed, the river will be diverted and the damsite exposed to the sun for the first time in centuries. The excavation of unsuitable foundation materials will then be made and it will be the latter part of 1934 before preliminary work can be completed and before the actual pouring of the concrete in the main structure can begin.

The Union Pacific Railroad constructed a line from its existing facilities at Las Vegas, Nev., to Boulder City, a distance of some 23 mi. Joining this, the United States Government built approximately 8 mi. of railroad to a point near the edge of the perpendicular walls of the Colorado River. Even before these facilities were completed, Six Companies Inc. provided additional railroad facilities involving about 22 mi. at a cost of close to $1,000,000. This latter line runs down along the Colorado River through a narrow vertical gorge to and through the damsite and involved heavy construction. The entire railroad system east of Boulder City will be operated by Six Companies Inc.



MOBILE JUMBO, supported on motor-truck chassis, carries battery of air drills for forming blast holes in rock invert section of diversion tunnels.

Railroad Transportation—Present analysis of the railroad transportation requirements indicates the need of about 11 locomotives. The heavy hauling demand will require 70 to 100 gravel cars and a complete railroad operation system. The traffic density on this construction railroad may possibly develop to be the greatest in the West.

A detailed study indicates that the railroad system during a period of five years will handle in the neighborhood of 33,000,000 tons of live load, necessitating haulage of approximately 440,000,000 ton-miles of dead and live load. This haul will require about 63,000 trains comprising more than 600,000 carloads of materials (equivalent to 4,500 mi. of solid freight cars) and about 700,000 locomotive-miles. The equipping and operating of the system, in addition to the construction, will cost an additional $2,000,000.

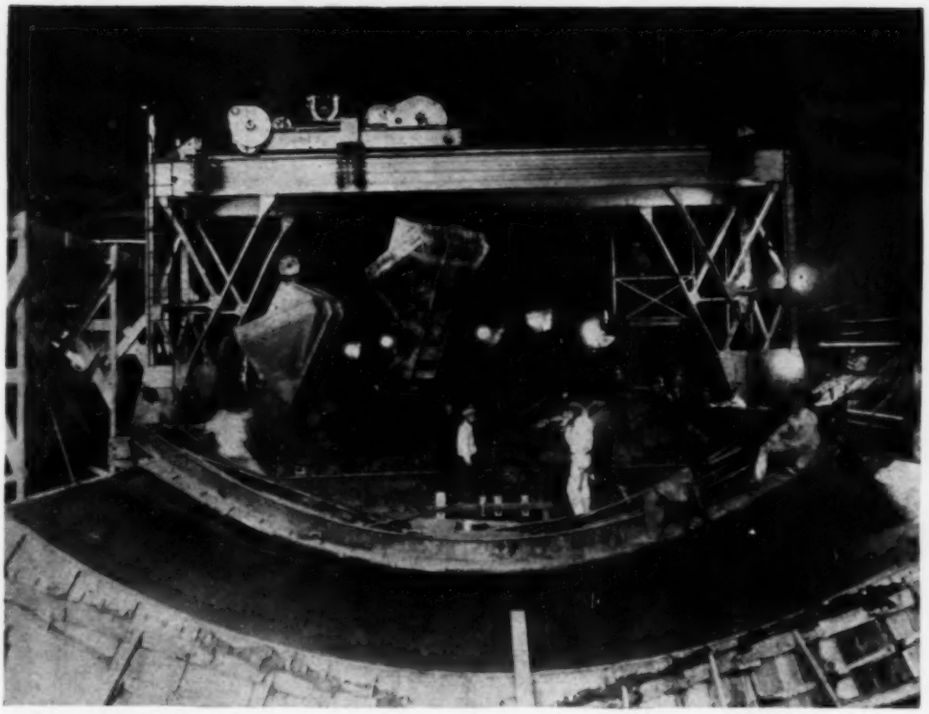
Construction Scene—From a high cliff above the damsite one looks down upon the yellow river—dark, silent, menacing—seemingly unconscious that the days of its tyranny are at an end. Along the black face of its granite walls there are tiny patches of movement, color, which, as the eye concentrates upon them, show men—pygmies in proportion to the great task upon which they labor. They have lowered themselves to ledges down a hundred feet of swinging ladders, anchored themselves to sunken iron rods by slender ropes, and, apparently unconscious of the heights above or depths below, labor to clean the walls, scaling threatening rock fragments, great and small, for the protection of their fellow workers below.

One sees a broad road literally hung on the ledge with full knowledge that the summer flow of the river will destroy every vestige of it; temporary bridges that will suffer the same fate; the steady stream of trucks carrying their 10-ton loads; overhead, giant cables from whose huge blocks 20 tons of men and equipment are swung from bank to bank.

To see this canyon by night is a rare experience that writes itself deep on the memory. Work on Hoover dam is literally continuous. Twenty-four hours a day, seven days a week, this relentless attack is carried on.

Morale—The one outstanding element

AT UPSTREAM PORTALS of 56-ft. diameter diversion tunnels Colorado River is spanned by timber pile trestle for transport of material.



LINING INVERT of a diversion tunnel. Concrete, delivered by motor truck in bottom dump buckets, is placed by electrically powered traveling gantry crane.

in the whole complex of forces, both physical and human, which are at work in this area, is the attitude of the men, the zeal and enthusiasm with which they do their part, their sense of "belonging," their understanding that they are a part of what already begins to be a great achievement. From a practical point of view this spirit could not exist if it were not obvious in the group as a whole that they are getting what they like to call a square deal. Their standard of subsistence is certainly well above that which is dictated by the nation-wide unemployment. The minimum wage is $4 a day for unskilled labor, ranging to $10 a day for skilled labor, with a proportionate scale.

However, mere money wages, important as they are, will not buy cooperation. The safety and health of these men has been a major consideration of the government, as planner, and of the contractors, as builders. It was inevitable at the launching of this undertaking that a certain percentage of the unhappy men who have no sense of attachment should move into this area. It was equally certain that when the vanguard moved in to break ground on this relentless desert, with its extremes of heat and cold, that there should have been a period of discomfort. Even the hardiest men find it difficult to work in many centers of population over the land where the temperature sometimes reaches 105 deg. F. Here on the desert site the average temperature for more than 90 days is well over 119 deg., with a minimum of 128 deg. Yet in less than eight months the region was so organized that every man engaged in the work is well housed and better fed than the great average of his fellows.

Housing — In dormitories that are steam-heated for the penetrating cold of the desert winters and ventilated with conditioned air, cooled and moistened, to produce the maximum comfort in the summer's heat, these men are supplied with individual rooms, comfortable beds, clean linen, electric lights, janitor service and modern toilet and bathing facilities in a way which marks a new high in the curve of construction-camp accommodations.

The dining room, through a singularly fortunate concession which is guarded by a contract that can be terminated on 24-hour notice, is serving better food than the average American home enjoys. At the present moment 6,000 meals a day with fresh milk, fresh butter, fresh meat, fresh vegetables, fresh fruits in abundance are served.

The new hospital on the hill has an equipment which would be the envy of many hospitals in metropolitan areas ten times the size of Boulder City. The emergency stations on the job, the ambulance service and provisions for first-aid, have all contributed to the minimizing of injury and fatalities.

The general store here has many units which far outrank those in towns of larger size, and although every pound and every package must be brought in over expensive rail and highway constructed for this special occasion, the prices are comparable with those of metropolitan markets. Not a single employee is compelled to buy at this store; there is absolute freedom for every individual to purchase in his own market and according to his own wishes, and this right is scrupulously guaranteed.

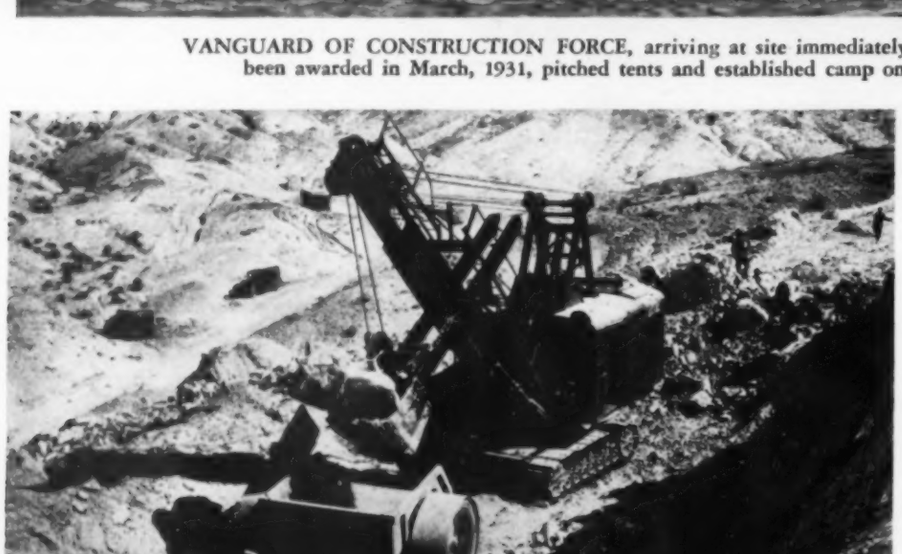
Police and fire protection, water supply and sanitation outrank the facilities of many communities of similar size. Recreation, education, opportunities for religious devotion and fraternal fellowship are provided.

This project is indeed a magnificent adventure, as thrilling as the Crusades and the first explorations. For many who take part in the actual manual labor it is vastly more hazardous than a trip to the South Pole. It calls for stamina and endurance; it demands skill and agility; it calls out loyalty and faith which always end in devotion. In this case the loyalty will be to the task, but it will be so because there is plan and direction behind it all, because devoted men, working silently and without fame, quicken the whole endeavor with their zeal and determination. Had the Prophet of old been telling this story, he would surely have said again, "For the people had a mind to work."

STEEL SUSPENSION BRIDGE supporting motor truck roadway crosses Colorado River canyon in vicinity of portals of diversion tunnels.

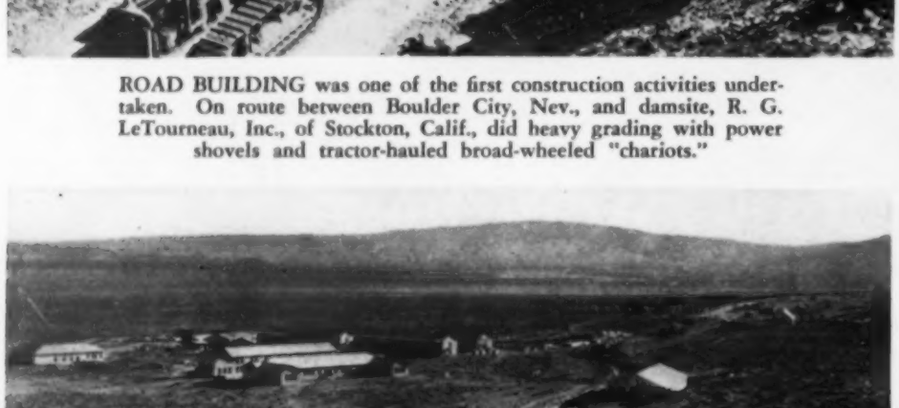
Pictorial Progress Record of
HOOVER DAM CONSTRUCTION

VANGUARD OF CONSTRUCTION FORCE, arriving at site immediately after Hoover dam contract had been awarded in March, 1931, pitched tents and established camp on bank of Colorado River.



ROAD BUILDING was one of the first construction activities undertaken. On route between Boulder City, Nev., and damsite, R. G. LeTourneau, Inc., of Stockton, Calif., did heavy grading with power shovels and tractor-hauled broad-wheeled "chariots."

TRANSMISSION LINE 230 mi. long was erected by Southern Sierras Power Co. to bring electric power to the job.



BOULDER CITY *(left)* begins to take form in Nevada desert about 6 mi. from site of dam in Colorado River canyon.

SEWER SYSTEM *(left)* for Boulder City is built with aid of trenching machine to serve a population of about 5,000. New Mexico Construction Co., Inc., of Albuquerque, N. M., contractor on this work, also installed water service lines and paved streets of Boulder City.

DAMSITE is in steep-walled canyon of Colorado River between Nevada (on right) and Arizona. Dam, 730 ft. high above foundation, will raise water surface 582 ft.

BUILDINGS to the number of nearly one thousand had to be erected to house the engineering and construction personnel at Boulder City, 6 miles from damsite.

WATER SUPPLY *(right)* for Boulder City is pumped from Colorado River into 200,000-gal. pre-sedimentation tank *(right)* equipped for mechanical removal of deposited silt. Clarified water is then pumped by two plants against 2,000-ft. head through 7 mi. of 10- and 12-in. pipe to distribution tank in city.

CONTRACTORS' WAREHOUSE *(left)* under construction at Boulder City by Six Companies Inc.

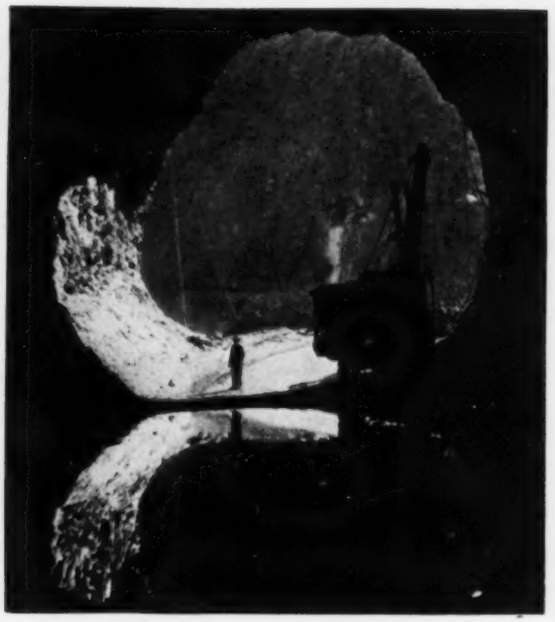
PORTAL of one of the four 56-ft. diameter diversion tunnels showing electric shovel loading muck into motor truck.

BOULDER CITY as it appears today. Municipality in Nevada desert for Hoover dam workers has paved streets, water and sewerage systems.

Ewing Galloway Photo

DIVERSION TUNNELS piercing rock of canyon walls have diameters of 56 ft. Immense size of bores is indicated by comparison with motor truck in portal at right. Each of the four tunnels will be lined with a 3-ft. thickness of concrete making their finished inside diameters 50 ft.

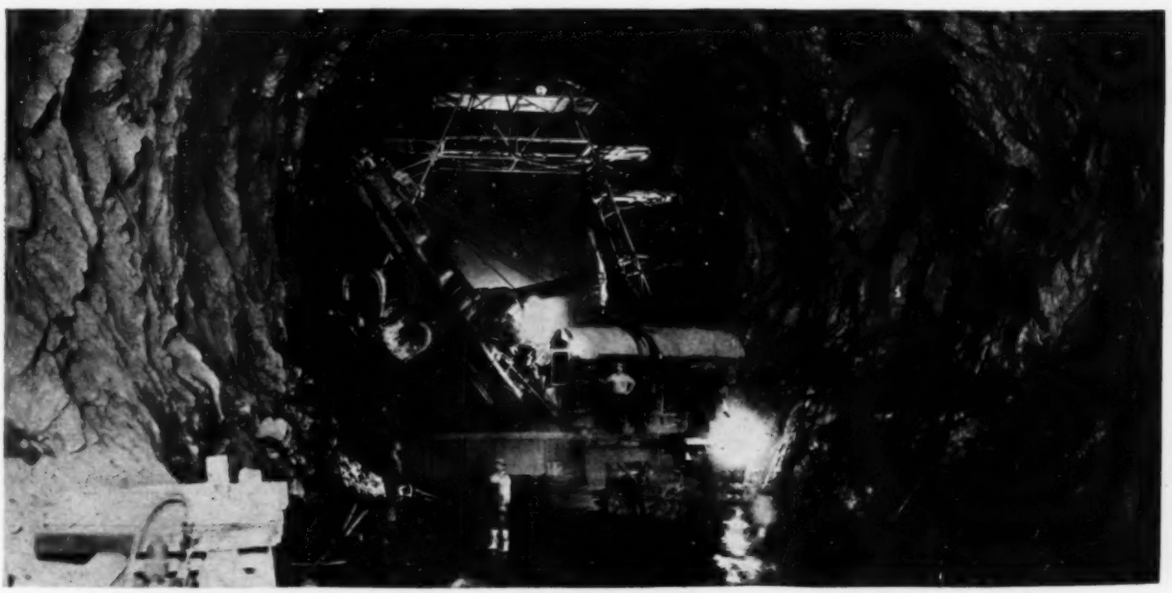
STEEL SUSPENSION BRIDGES below diversion tunnel downstream portals carry motor trucks and compressed air pipe lines across Colorado River Canyon. Damsite is at upper left hand corner of photograph.



SIZE of 56-ft. bore for diversion tunnel is reflected by height of man standing alongside power shovel at portal.

AGGREGATE PLANT 4 mi. above damsite has capacity of 500 tons per hour. Belt conveyors deliver gravel to screens, which separate material into sizes varying from 9-in. cobbles down to sand.

CONCRETE MIXING PLANT, equipped with four 4-yd. mixers, is 78x118 ft. in plan and uses bulk cement. Batching is automatically controlled. Plant will produce total of 4,500,000 cu.yd. of concrete

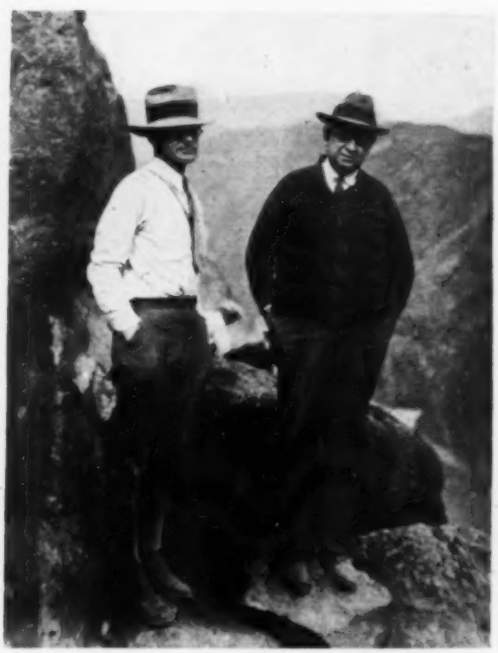


EXCAVATING INVERT of one of the 56-ft. diameter diversion tunnels. Electric power shovel loads blasted rock into motor truck. In background is steel-frame jumbo for trimming and scaling rock prior to placing concrete lining.

Present and Accounted For —

Hoover Dam Personalities

DR. ELWOOD MEAD, commissioner, Bureau of Reclamation, Department of the Interior, is in general charge of the Boulder Canyon project for the Federal Government.

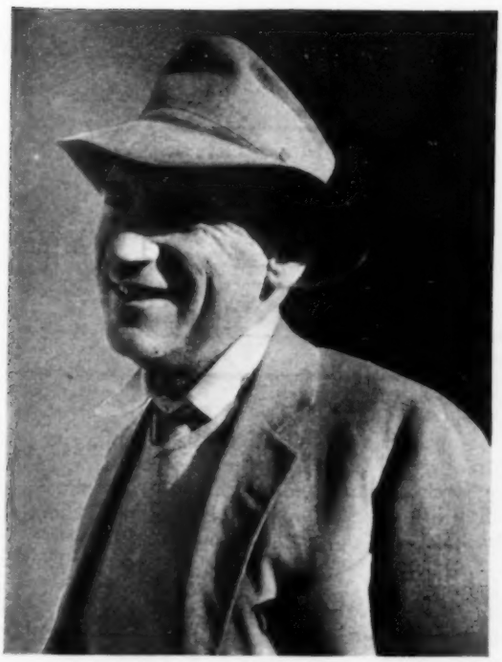


WALKER R. YOUNG *(left)* is construction engineer, with headquarters at Boulder City, Nev., and RAYMOND F. WALTER, chief engineer, for the U. S. Bureau of Reclamation.

HOOVER DAM BUILDERS, representing Six Companies Inc.., the contractors, and U. S. Bureau of Reclamation. *(Left to right)* NORMAN S. GALLISON, public relations director, and H. J. LAWLER, director, Six Companies; WALKER R. YOUNG, construction engineer, Bureau of Reclamation; CHARLES A. SHEA, director, and E. O. WATTIS, vice-president, Six Companies; COMMISSIONER ELWOOD MEAD, Bureau of Reclamation; FRANK T. CROWE, general superintendent, Six Companies; RAYMOND F. WALTER, chief engineer, Bureau of Reclamation; W. A. BECHTEL, president, Six Companies.

Wide World Photo

WHEN NEWS OF THE AWARD of the $49,000,000 Hoover dam contract was received by executives of Six Companies Inc., at San Francisco. *(Left to right seated)* E. O. WATTIS, W. H. WATTIS and W. A. BECHTEL. *(Standing)* H. J. LAWLER, CHARLES A. SHEA, S. D. BECHTEL, FELIX KAHN and K. K. BECHTEL.



CHARLES A. SHEA, secretary and director of construction for Six Companies Inc., and representative, in the consolidated organization, of the J. F. Shea Co., of Portland, Ore.

FRANK T. CROWE, general superintendent for Six Companies Inc. After graduating from the University of Maine in 1905 Mr. Crowe served with the U. S. Bureau of Reclamation and, later, with a number of prominent western contracting organizations, including the Morrison-Knudsen Co., of Boise, Idaho, and the Utah Construction Co., of Ogden, Utah.

ORGANIZATION *of Six Companies Inc.*

SIX Companies Inc., the combination of six established Western contracting firms assembled expressly for building Hoover dam, is a unique construction organization. This group presented the low figure of $48,890,995 for building the Hoover dam project when bids were opened by the Bureau of Reclamation in Denver, March 4, 1931. The two other bids presented were by The Arundel Corporation and associates, $53,893,879 and by Woods Brothers Corporation, $58,653,108. Member organizations of the Six Companies Inc. are:

Utah Construction Co., Salt Lake City, Utah.
W. A. Bechtel Co. and H. J. Kaiser, San Francisco, Calif.
MacDonald & Kahn Co., San Francisco, Calif.
J. F. Shea Co., Portland, Ore.
Pacific Bridge Co., Portland, Ore.
Morrison-Knudsen Co., Boise, Idaho.

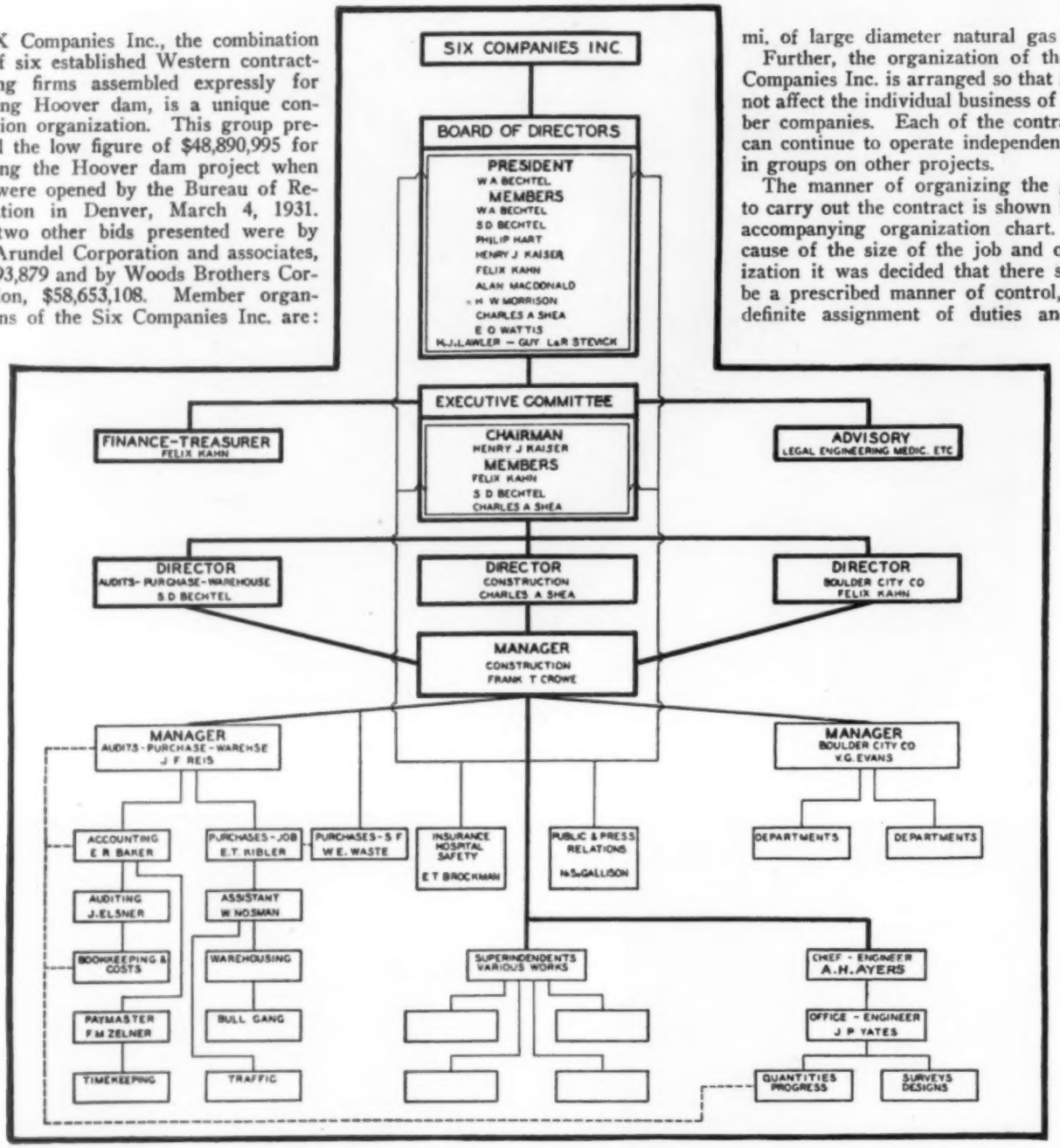
A syndicate of contracting organizations appeared the logical solution for bidding on and building Hoover dam. It was also important that the participating firms have prior experience in working together. About two months before bids were received, the Six Companies Inc. was definitely conceived and agreed upon by the interested companies. Final arrangements involving field investigations, estimating and finances were concluded in specific form about two weeks before bids were scheduled to be opened.

No one of the member companies holds or controls a majority of the stock of Six Companies Inc. Participation in the organization is in proportion to the stock owned. All of the group are of long standing in the construction industry in the West and their operations extend over 37 states and three foreign countries. Briefly, the member companies have undertaken more than 4,000 contracts, all of which have been successfully concluded, involving about $450,000,000. They have built 25 dams, 5,000 mi. of railroad, 2,000 mi. of highway, 1,800 bridges, 275 tunnels totaling 300,000 ft., excavated 500,000,000 cu.yd. of material, built 276 buildings and constructed 700 mi. of large diameter natural gas lines.

Further, the organization of the Six Companies Inc. is arranged so that it will not affect the individual business of member companies. Each of the contractors can continue to operate independently or in groups on other projects.

The manner of organizing the group to carry out the contract is shown in the accompanying organization chart. Because of the size of the job and organization it was decided that there should be a prescribed manner of control, with definite assignment of duties and responsibilities. Final authority rests with the Board of Directors which contains representatives of all six companies. Through an Executive Committee and a Director of Construction the work is handled by the Manager of Construction. Various directors are in charge of features of finance, purchasing, transportation, operation of Boulder City, etc. The purpose and effect of this scheme of organization is to make available the particular qualifications of the best men of each of the member companies.

The outline of the organization presented here is part of an address by S. D. Bechtel before the San Francisco Section, American Society of Civil Engineers.



A *Common-sense* BASIS for judging rope cost

Seldom is a rope user interested merely in the service given by a single wire rope. To the contrary, and particularly if he uses ropes in sizeable quantity, he is concerned about the performance of his ropes as a whole, about their *Average Service.*

This is at once the common-sense and most exacting basis for judging wire rope service cost. It is the basis advocated by Roebling, in which rope cost per ton of material handled, per mile traveled, or per other unit of service measurement, is based not on the service of a single rope but on the *average* service of several ropes.

Roebling Wire Ropes are made to give *uniformly* good service. No wire ropes, regardless of make or construction, will show lower general-average operating costs.

JOHN A. ROEBLING'S SONS COMPANY, TRENTON, N. J.

Wire · Wire Rope · Copper & Insulated Wires & Cables · Welding Wire · Flat Wire · Wire Cloth & Wire Netting

Atlanta Boston Chicago Cleveland Los Angeles New York Philadelphia Portland, Ore. San Francisco Seattle Export Dept., New York, N. Y.

A plain statement about Wire Rope Economy

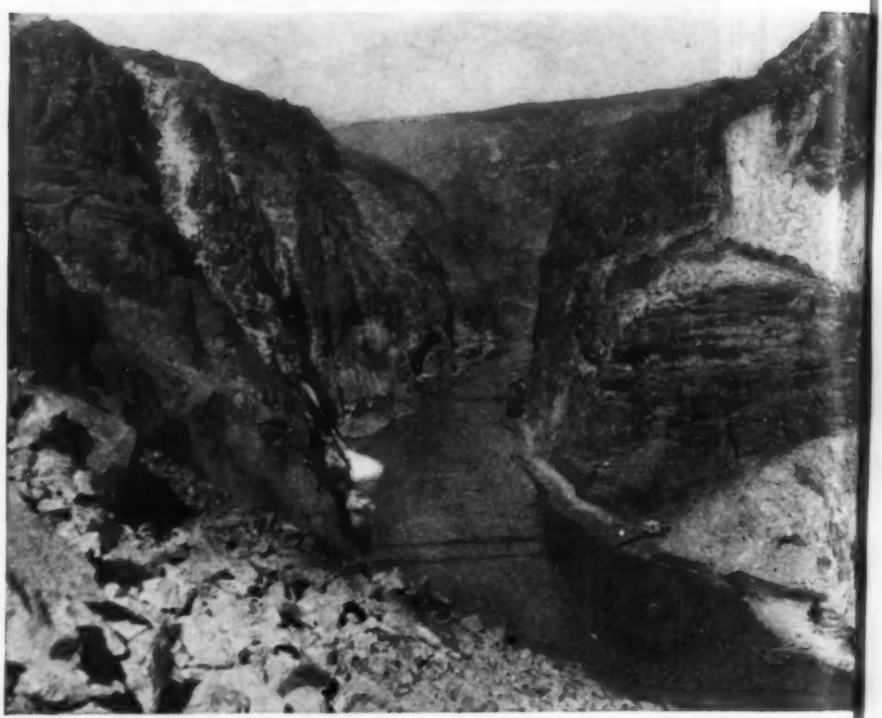
Roebling does not indulge in nor encourage sweeping claims of superior wire rope economy. Such claims, if generally made, would merely confuse the rope user. ¶ For the guidance of rope buyers, however, Roebling does assert that when gauged by the work performed, NO wire rope, regardless of make or construction, will show lower general average operating costs than Roebling.

Wire Rope for all purposes

The importance of selecting the right rope for each use cannot be too strongly emphasized. For no one rope will meet all requirements. ¶ Roebling makes wire rope of a great variety of types and designs, including Standard Right, Left, Lang, Preformed and Alternate Lays, in all degrees of rope and strand flexibility. ¶ The great stamina of all Roebling Ropes is primarily due to the quality of Roebling Wire. This Acid Steel Wire is renowned for its fatique resisting and wearing qualities. No better rope wire is produced. ¶ "BLUE CENTER" STEEL is the highest grade and is generally recommended for severe duty.

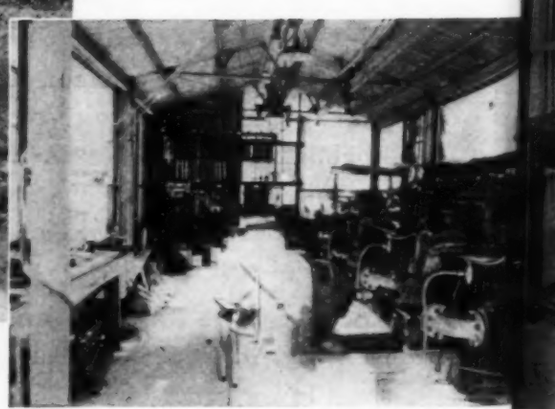
JOHN A. ROEBLING'S SONS COMPANY

G-E Motors and Control



General view of the gigantic Hoover Dam project being carried on by Six Companies, Inc., on the Colorado river

Pumps that must not fail! And again G-E motorized. Boulder City and the Hoover Dam are entirely dependent upon these Buffalo Steam Pump Company pumps motorized by G.E. and mounted on a carriage, for their water supply



Government pumping station equipped with six pumps motorized by General Electric. Right: three G-E motors operating Byron-Jackson pumps in government pumping station

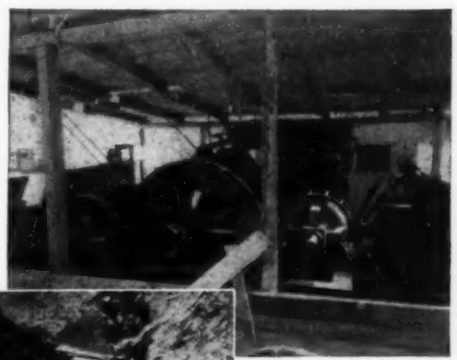
GENERAL

help speed the Hoover Dam

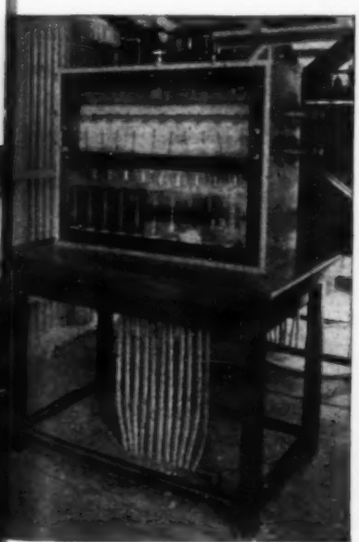
SIGNIFICANT is the fact that General Electric motors and control were selected for many important jobs on this great project. Significant, because in this undertaking, as in others, the value of the RIGHT MOTOR and the RIGHT CONTROL has again been recognized.

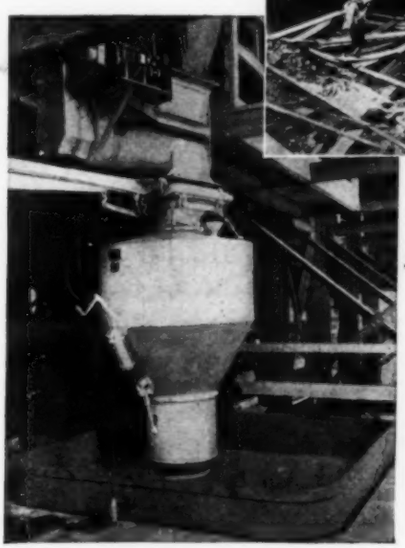
There's always one General Electric combination of motor and control exactly suited to the need, and built to one purpose: to match the driven machine. That's why G-E motor and control equipment lasts so long, is so free from trouble and expense, is so highly satisfactory — at all times.

Remember: A LAGGING JOB IS A LOSING JOB—whether you are building a mighty dam or a towering skyscraper. Specify General Electric equipment; its assurance of smooth, unfailing power is your assurance of getting the job done on time. General Electric Company, Schenectady, New York. Sales and engineering service in principal cities.



Above: This G-E wound-rotor induction motor operates one of the temporary cableways for handling materials in the construction of the diversion tunnels —another job where unfailing dependability is essential





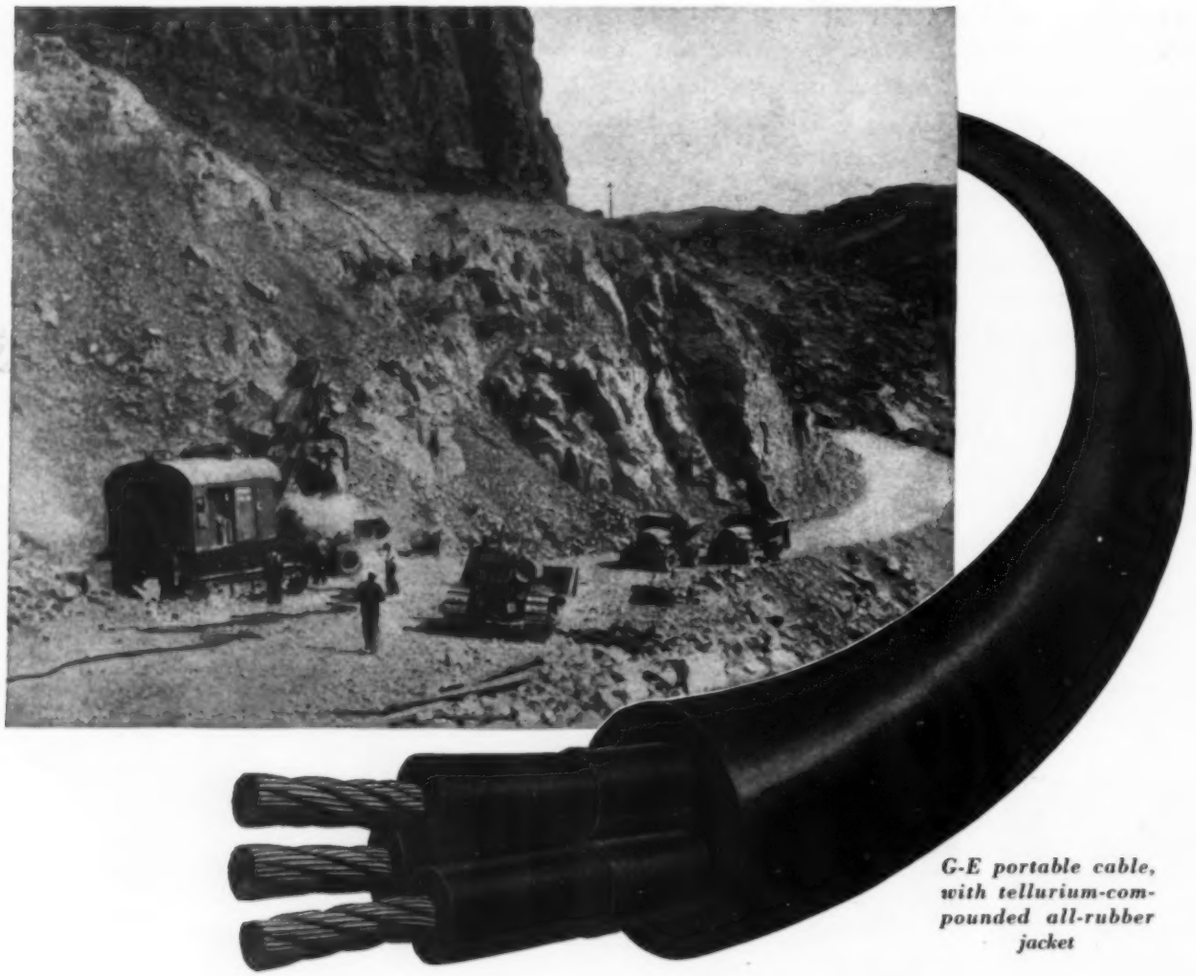
Above: Here is a large G-E induction motor helping the contractors sink a foundation for the permanent trash rack at the intake of No. 2 diversion tunnel

Left two views: Concrete of absolutely uniform proportions and strength is required by the government for Hoover Dam. Consequently, four C. S. Johnson Company automatic cement-weigh batchers, equipped with G-E motors and control were specified by the contractors. The weight of each ingredient and the consistency of the concrete for each batch is automatically recorded

200-642

ELECTRIC

7 Miles of G-E Cable
Rides the Rocks of Hoover Dam



G-E portable cable, with tellurium-compounded all-rubber jacket

OVER razor-sharp rocks—up and down hills and around corners—the big portable cable which supplies power to the electric shovels follows them about the dam.

Tractors and trucks may run over it, picks and shovels may hit it—without hurting it—because this G-E cable is built to stand such rough usage. It has a tellurium-compounded, all-rubber jacket that is *tough*.

On the Hoover Dam job, there are about seven miles of G-E portable cable, in 3- and 4-conductor, 2300- and 2500-volt types—the largest order ever placed for such high-voltage portable cable.

General Electric insulated cable is available in every type, size, and voltage for every application. Address the nearest distributor or G-E sales office. General Electric Company, Schenectady, N. Y.

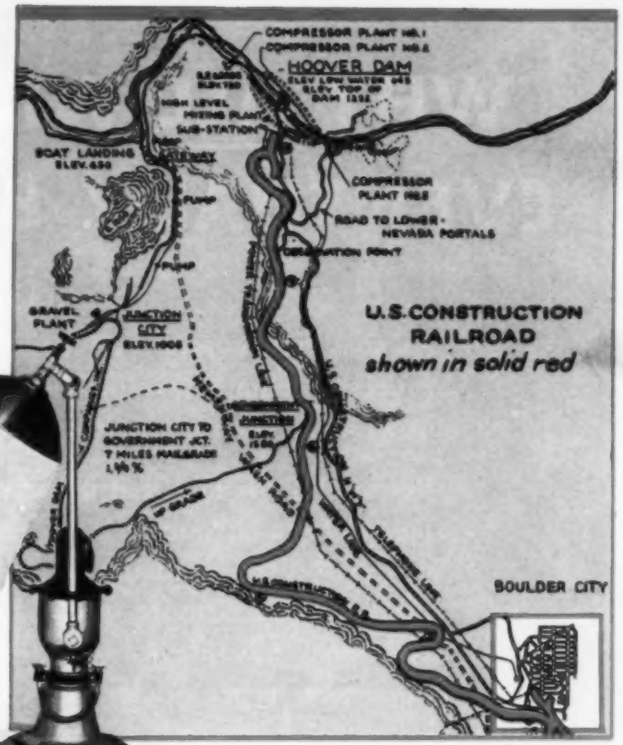
810 23

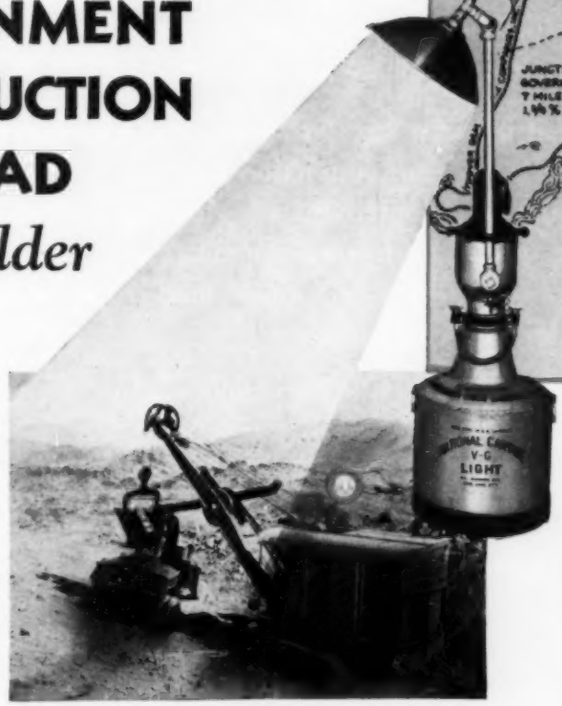
GENERAL ELECTRIC

NATIONAL CARBIDE

V-G LIGHTS

HELPED BUILD THE GOVERNMENT CONSTRUCTION RAILROAD *from Boulder City to* HOOVER DAMSITE





Used by
LEWIS
CONSTRUCTION
COMPANY

National Carbide Lights are the ideal source of high power, economical lighting—not only for general construction work but also for water companies, shipyards, quarries, railroads, tunnels, subways, telephone companies and municipalities. One of their chief advantages is the ease and convenience of recharging with handy CARBIDE. You always know exactly how long they will run at maximum. Fresh CARBIDE can be put in in a few minutes . . . . no wires, etc., to connect or trip over, no matter where you put them and this light is not easily overturned. For their tremendous light volume they are *lighter* in weight.

National Carbide V-G Lights mean most white light from least carbide—no waste-matter to be paid for or left over. No excess carbide in water to heat it up and make flame red.

No waste carbide, whether used intermittently or continuously. They have proved their safety, economy and efficiency.

Write for Booklet "Lights" on complete line of V-G Lights, V-G Handy Light and National Carbide Lantern. A Light or Lantern for every purpose.

Send for Illustrated Booklet "Lights"

NATIONAL CARBIDE SALES CORP.
Lincoln Bldg., New York

8000 C. P.
for 12 hours
NATIONAL CARBIDE
V-G LIGHT
PORTABLE DAYLIGHT
NO WASTE

X-100 showing extension for the BIG JOB

Y-199 where a powerful light is needed

WLI-CI
National Carbide
Lantern

Specify
National Carbide
RED DRUM
Coast to Coast
Distribution

WHY ALL WIRE ROPE WILL EVENTUALLY BE PREFORMED

Every wire rope will eventually be Preformed irrespective of its size, type, grade and construction because the Preforming process* eliminates the destructive internal stress which is inherent in *every* wire rope that is *not* Preformed.

Because of the fact that internal stress shortens the life of every *non*-preformed rope, it is my firm conviction that the Preformed process* will eventually be adopted by all wire rope manufacturers. What is more, every Preformed rope has the following additional advantages over every *non*-preformed rope of the same size, type, grade and construction:

1. Less internal friction.
2. Each strand carries its share of the load.
3. Less slippage.
4. Resists kinking.
5. Cuts without seizing.
6. Easier to handle.
7. Easier to splice.
8. Makes Independent Wire Rope Center practical.
9. Makes "Lang Lay" practical.

G. O. Moon
VICE-PRESIDENT

AMERICAN CABLE COMPANY, *Incorporated*
230 Park Avenue, New York, N. Y.
Manufacturers of TRU-LAY—the original Preformed Wire Rope

* *55 Wire Rope Manufacturers throughout the world are now licensed to manufacture Preformed Wire Rope under American Cable Company's patents.*

BOULDER CITY

The Wonder City Sprung from Desert Sands!

WHO PAVED *its Streets and Sidewalks* **?**

The paving of streets and sidewalks and the laying of water mains and sewers at Boulder City was done by the New Mexico Construction Co. A general view of Boulder City is shown in the above photograph

WHO LAID *The Sewers and Water Mains* **?**

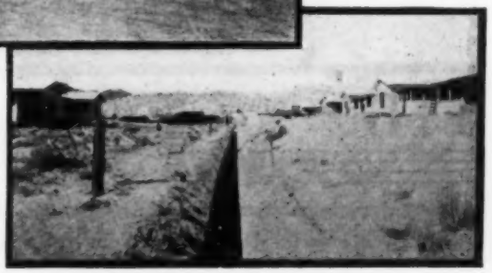
NEW MEXICO CONSTRUCTION CO.

ALBUQUERQUE, N. M. **DENVER, COLO.**

An organization fully equipped with men and machinery efficiently to complete without sub-contracting. All municipal improvements, reservoirs, dams, sewers, water-works, paving of all types, highways, airports, railroads, siphons, conduits and diamond drilling. Also producing and marketing "SANTA ROSA ASPHALT ROCK" from the largest available deposit in the world near Santa Rosa, New Mexico.

"THE PATH OF PROGRESS IS PAVED"
"WARRENITE-BITULITHIC PAVEMENT"

Typical street scene at Boulder City



Laying sewers at Boulder City

WE ARE JUSTLY PROUD TO BE LISTED IN THE HONOR ROLL OF THOSE ENGAGED ON THE HOOVER DAM PROJECT

Pulling 14 in. arch web Lackawanna Piles, 30 ft. long from the cofferdam of the Holyoke Water Power Co.

P. J. Kennedy & Co., Inc., Contractors, Holyoke, Mass.

Built for ONE JOB— PULLING PILES

The Vulcan Piling Extractor is designed for just one purpose—pulling piles. It cannot be used for driving.

But it is always ready to do a quick and economical pulling job. It needs no especial rigging or leads, does not have to be reversed like a double purpose hammer.

Even after the pile is out of the ground, the Vulcan Extractor proves its convenience. Connection to the pile is made through a universal joint which permits the pile to be laid down and disconnected without the usual difficulty.

Designed with but a single moving part, with substantial cross arms and side bars, the Vulcan Extractor gives little trouble under the severest service conditions.

It will frequently pay for itself on a single job.

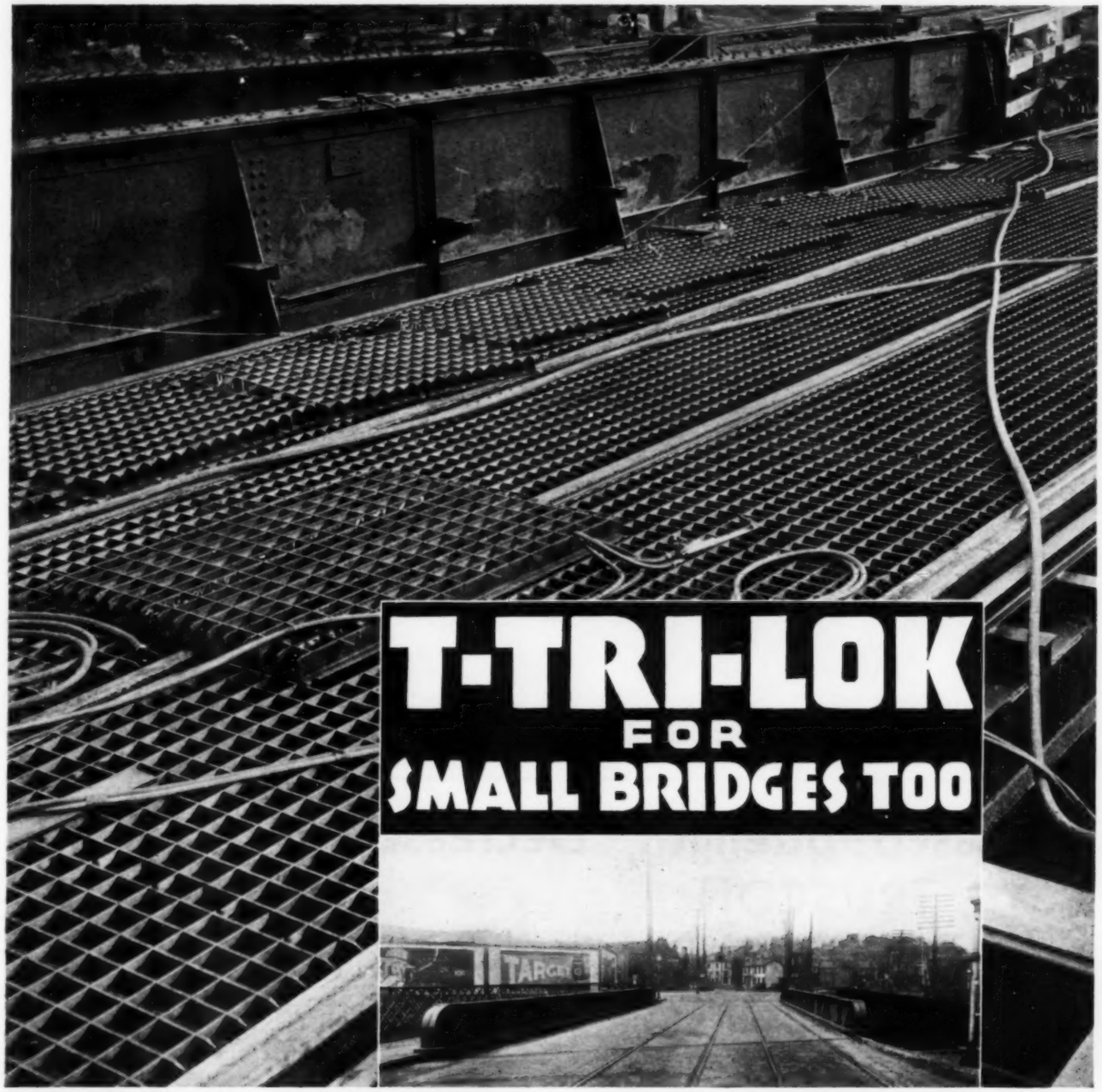
Vulcan Iron Works
327 No. Irving Ave., Chicago, Ill.

Representatives for California, Nevada, and Japan:
Harron, Rickard & McCone Co.,
1600 Bryant St., San Francisco, Calif.

Southern Representatives:
Woodward, Wight & Co., Ltd.,
451 Howard Ave., New Orleans, La.

Representatives for Washington and Oregon:
A. H. Cox & Co.,
1757 First Ave., South.
Seattle, Wash.

THE VULCAN EXTRACTOR



Small bridges become vitally important when their reconstruction or resurfacing necessitates detouring of main highway traffic. In such cases, T-TRI-LOK helps speed up the job. One case is reported where a T-TRI-LOK resurfacing job was completed and opened for traffic in 48 hours!

T-TRI-LOK is furnished in standard units in widths up to 4 feet and in lengths up to 40 feet. After the units are secured to bridge stringers, the cells are filled flush with concrete, forming an armored concrete, anti-skid wearing surface of long life and high efficiency. If you are interested in rapid bridge floor construction, send for our T-TRI-LOK booklet.

CARNEGIE STEEL COMPANY

Subsidiary of United States Steel Corporation

PITTSBURGH, PA. 188

Send for your copy TODAY

Here's a new handbook for contractors, architects, engineers, building superintendents—112 stiff-bound pages of valuable information—35 pages of detailed formwork drawings—60 pages of useful tables—17 pages of miscellaneous data. Here are a *few* items selected at random:

Absorption of Aggregates
Board Measure
Capacities of Tanks
—Round
—Rectangular
Circles—Areas
—Circumferences
Clips Required for Guy Ropes
Decimal Equivalents
Weights of Materials
Metric Measure
Mortar and Stucco Covering Capacity
Reinforcing for Silos
Ropes for Hoist Towers
Wire Rope Strength
Squares and Square Roots
Reciprocals
Concrete Quantities
Stair Forms

A mass of important data, including detailed directions on how to cut costs by using Marion form ties, spreaders, wire tighteners, cable clips, hex couplings, inserts, tank lugs and malleable washers. But of the 112 pages, only nine are devoted to Marion products.

Priced to sell at $1.00, a copy will be sent for 25c to any contractor, engineer, architect, building superintendent, boss carpenter or other person interested in construction work.

Marion Malleable Iron Works
913 Miller Ave. · Marion, Ind.

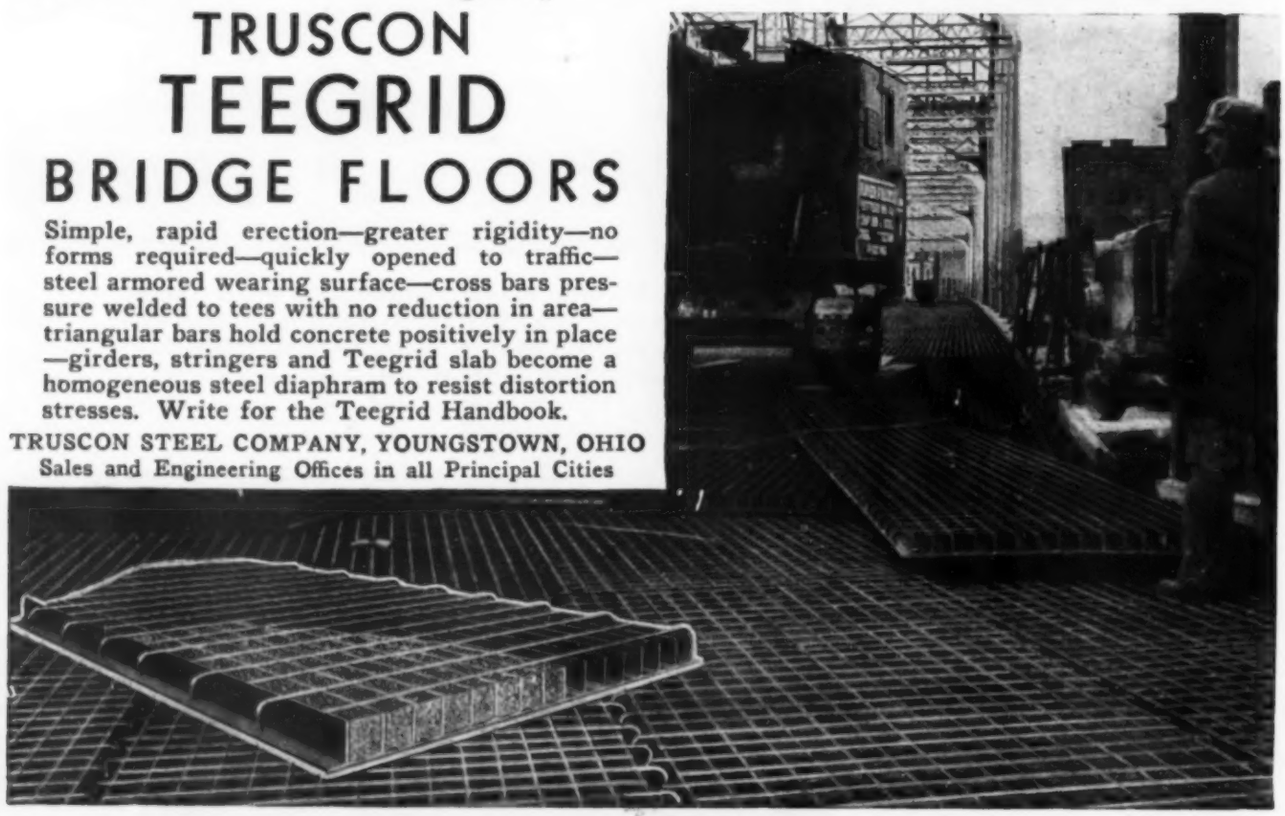
(104)

Increased Strength, Decreased Dead Load

TRUSCON TEEGRID BRIDGE FLOORS

Simple, rapid erection—greater rigidity—no forms required—quickly opened to traffic—steel armored wearing surface—cross bars pressure welded to tees with no reduction in area—triangular bars hold concrete positively in place—girders, stringers and Teegrid slab become a homogeneous steel diaphram to resist distortion stresses. Write for the Teegrid Handbook.

TRUSCON STEEL COMPANY, YOUNGSTOWN, OHIO
Sales and Engineering Offices in all Principal Cities



At the Hoover Dam—at every big construction job—the Stop-Watch plays an important part.

Illustrated, No. 302
Gallet Time Study Stop-Watch

GUINAND and GALLET STOP-WATCHES

Save Moments that mean Saved Money!

On the country's big Public Works projects, as well as in smaller jobs, Guinand and Gallet Stop-Watches help to achieve important economies in the planning and analysing of all operations.

In money and labor saved, a dependable Stop-Watch will earn its cost many times over. And Guinand and Gallet Stop-Watches have proved their dependability through 50 years of recognition as "Standard the World Over." *Investigate.*

WRITE FOR CATALOG OF INDUSTRIAL STOP-WATCHES

JULES RACINE & CO., 20 West 47th St., New York
Kindly forward catalog CMA on Stop-Watches for construction use.
Name .....
Address.....**City & State**.....

Dietz Lanterns & Torches

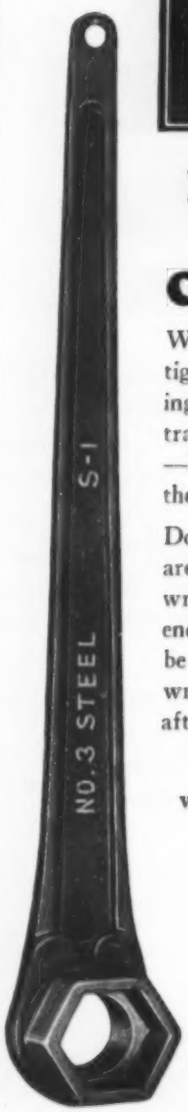
The red light of a Dietz Lantern, a danger signal universally recognized, and the white light of a Dietz Torch—these afford a choice of leading lights for night warning that meet every requirement of safety to persons and protection to property.

Dietz Red Lanterns, for contractors' use, assure the highest degree of lighting power and burning dependability. Their flaming red warns in the only color that means DANGER.

Dietz Highway Torches, fitted with Dietz All-Weather Burners, assure the utmost illumination and freedom from blow-outs that is obtainable from an exposed oil flame.

The next time you order Lanterns or Torches, get the most for your money by specifying Dietz make.

R. E. DIETZ COMPANY
NEW YORK
Makers of Lanterns for the World
FOUNDED 1840



IN TUNNEL or SUBWAY CONSTRUCTION

When husky wrenches are needed for tight places,—when heavy back breaking tools are required for leverage, contractors turn to LOWELLS. Why?—look at those huskies with backs to the Job.

Do you realize that the bolt and nut are holding the business end of that wrench up? Some saving over an open end wrench, man, when they'd have to be holding the whole weight of the wrench, and turning around to refit after every pull.

Consider these statements when buying Heavy Wrenches

Send for Catalog R for complete information

LOWELL WRENCH CO.
WORCESTER — MASS.

On the Job at HOOVER DAM

THE Six Companies take no costly chances. They measure all cable loads quickly, easily and accurately with the Martin Decker

TENSION INDICATOR

Engineers and other executives desiring data regarding this money saving safety device please address Dept. W.

Martin-Decker Corporation
3431 CHERRY AVENUE LONG BEACH, CALIF., U. S. A.

MEN RESPECT THE GENERAL

because it is THE LARGEST, STRONGEST, FASTEST and MOST POWERFUL half-yarder in the field. It HAS EXTRA POWER (powered with a 62 H. P. slow speed engine) AND STAMINA that enables it to "tie-into" the toughest kind of jobs and come through SHOWING GOOD PROFITS.

GENERAL EXCAVATORS

SHOVEL - DRAGLINE - PULLSHOVEL - CLAMSHELL - CRANE - SKIMMER

MARION, OHIO, U.S.A.

DISTRIBUTORS IN ALL PRINCIPAL CENTERS—GENERALS EVERYWHERE

WHAT A *Parking Space!*

In appearance, smooth as a well-kept lawn . . . in reality, a hard, waterproof, dustless surface with gripping power that stops skidding before it can start. And how quickly and economically it was laid! Simply a base of crushed stone, gravel or slag with a full penetration of Colas—the uniform, cold asphalt emulsion. Colas is being used from coast to coast. Its uniformity, dependable "breaking" point and its ease of application answer many road building problems. Shell technical men everywhere will work with you . . . without obligation.

SHELL OIL COMPANY
San Francisco

SHELL PETROLEUM CORPORATION
St. Louis

SHELL EASTERN PETROLEUM PRODUCTS, Inc.
New York City

Licensees of Colas Roads, Inc., New York City

3 uses for THE DORR WAY at the HOOVER DAM

The sewage treatment plant is shown at the top. On the left is the presedimentation Dorr Clarifier, and below is the water treatment plant. At the right is one of the Dorr Bowl Classifiers in the washing plant.

The U. S. Government and Six Companies, Inc. are using Dorr Equipment in several interesting ways on this great project—the largest single engineering job ever undertaken in the United States.

WATER TREATMENT —**In the water treatment plant constructed by the Government for Boulder City, three Dorr Clarifiers and four Dorr Mixers are in operation.**

The Six Companies, Inc. operates a Clarifier for removing silt from river water, which is used for concrete mixing and locomotive boiler feed.

SEWAGE TREATMENT —**The vital matter of proper sanitation is being taken care of by a modern separate sludge digestion plant. A Dorr Clarifier and gas-collection type Dorr Digester are installed.**

SAND PREPARATION —**For the important work of preparing aggregate, Six Companies, Inc. uses three Model F Bowl Classifiers to remove fine material. A Dorr Traction Thickener clarifies and recovers about 85% of the water from the washing operations.**

Faced with a heavy penalty for failure to meet any agreement, the contractors could not afford to take chances in selecting equipment. The choice had to be governed by demonstrated ability to produce satisfactory results with low operating costs.

The extensive and varied uses of Dorr Equipment on this notable project, again show that it pays to "Use the Dorr Way".

THE DORR COMPANY, Inc.

247 Park Ave. *Engineers* New York

Chicago Los Angeles

DORRCO

Denver Toronto

Don't

tear up the street

Bore the hole instead of trenching

Antiquated trenching and pipe-jacking methods of installing underground pipe are costly and wasteful. The watchword of today is "Save with Safety" and Hydrauger completely fulfills those requirements. Open trenches have cost many lives through traffic accidents; cut-up pavements have already cost far too many dollars. Hydrauger finds daily use in many of the more progressive and efficient cities throughout the country. Complete information is in our Bulletin; send for your copy today!

THE HYDRAUGER CORPORATION
233 Broadway, New York City

HYDRAUGER
"The Mechanical Gopher"

TRUSCON STEEL LINER PLATES

For tunnels, caissons, shafts, sewers and other permanent underground construction. Low cost, safety and speed are features. Write for data.

TRUSCON STEEL COMPANY
6100 TRUSCON AVENUE, CLEVELAND, OHIO

INTERNATIONAL TRUCKS

Do the Heavy Work at Hoover Dam

Above: A new armored International Model A-7 working 24 hours a day at the dam. This capacity load of wet gravel has come 8 miles to Boulder City, the full distance in third gear, with atmospheric temperature 112 degrees, engine heat indicator never over 190 degrees. This is one of several new Internationals just bought by Six Companies Inc.

From the first shovelful in the virgin canyon the International fleet has worked its way through the gigantic excavation program. *Above:* One of the first trucks—on the job 15 months.

Above: This is the new heavy-duty International A-7, same model shown at top, as sold for average hauling service. International sizes range from ¾-ton up. Sales and service through 188 Company-owned branches and many dealers. Full information on request.

THE STORY of transportation in the construction work at Hoover Dam resolves itself down to this fact: International Trucks are handling by far the major part of the stupendous hauling contract, reflecting everlasting credit on the performance and economy of the trucks and on the engineering and servicing organization of International Harvester.

Six Companies Inc., calling on its combined experience, chose Internationals against the field. As the work progressed, more units were put in service until the number of trucks bearing the triple-diamond emblem practically doubled all other makes combined. As this is written, word comes of delivery of several additional Internationals.

The rugged International fleet on the job month after month is supplying the most spectacular action in the blistering canyon and on the steep grades. The armored trucks have earned not only the admiration of every observer from driver to news cameraman but also the full confidence of the close-figuring contractors behind the scenes. From the outset right down to date the lion's share of performance and credit is given to International.

INTERNATIONAL HARVESTER COMPANY
606 So. Michigan Ave. **OF AMERICA** *(Incorporated)* **Chicago, Illinois**

The

AMERICAN SURETY COMPANY

OF NEW YORK

was one of the five surety companies privileged to handle and place suretyship in connection with a contract in the amount of $48,810,995 required by the

SIX COMPANIES, INC.

on the

HOOVER DAM PROJECT

and was also privileged to handle and place for

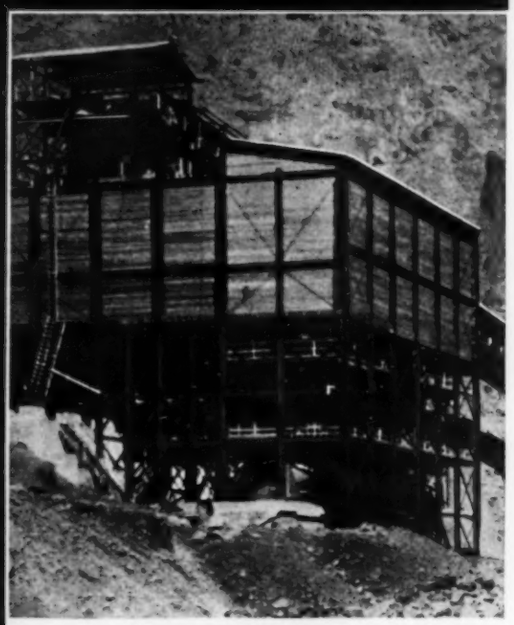
BABCOCK & WILCOX COMPANY

suretyship in connection with a contract in the amount of $10,908,600 for furnishing and installing penstock on on this project.

We solicit the opportunity of demonstrating the value of our service on Contract Bonds, other classes of suretyship and casualty insurance.

FORTY BRANCH OFFICES IN PRINCIPAL CITIES OVER 15,000 LOCAL REPRESENTATIVES

TO BATCH 4,500,000 cu. yards concrete —*automatically* for HOOVER DAM



Low-Level Batching and Mixing Plant for Hoover Dam in Which 80% of the Concrete for the Dam Will Be Mixed, Equipped with Johnson Automatic Batcher

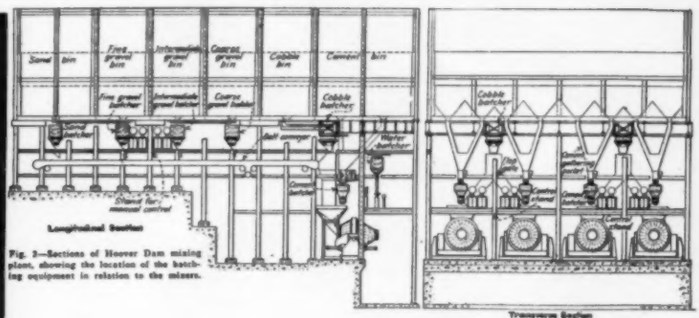
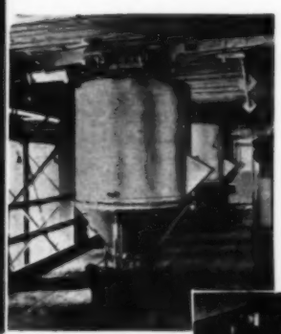


Fig. 2—Sections of Hoover Dam mixing plant, showing the location of the batching equipment in relation to the mixers.

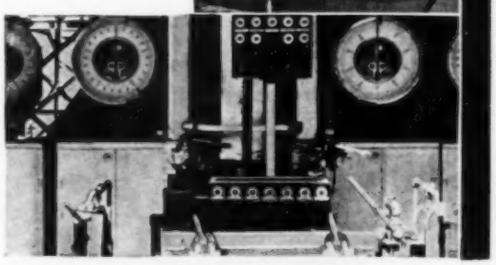
Sections of Hoover Dam Batching and Mixing Plant

280 cu. yards per hour!



Battery of Johnson Aggregate Batchers

Johnson Cement Batcher, Air Operated Discharge Gates



Operator's Control Station

JOHNSON AUTO-WEIGHT BATCHERS in the main HOOVER DAM MIXING PLANT are fulfilling the most rigid and elaborate specification ever written for concrete work.

Equipment had to be built especially for the job.

The C. S. Johnson Company, as volunteered to us by the Contractors' organization, were "selected as the one Company who could fulfill the requirements."

The Hoover Dam Batchers are TRULY AUTOMATIC AND EXTREMELY ACCURATE. The "Major" and "Final" Stream Flow Operation principle is employed rather than attempts to "catch over-run." Guess-setting of scales is avoided. Actual batch weights (not scale settings) are recorded. Consistency of the mix in the mixer is automatically indicated and recorded for the first time and proving very valuable.

Equipment covered by patents and patent applications.

Full details gladly furnished for jobs warranting such equipment.

C. S. JOHNSON CO., :: CHAMPAIGN, ILL.

JOHNSON

BINS and BATCHERS

"THEY SAY"

McGRAW-HILL

New York · Boston · Philadelphia · Washington · Greenville

Business men, industrialists and engineers regularly read the McGraw-Hill Publications. More than 3,000,000 use McGraw-Hill books and magazines in their business.

Radio Retailing
Food Industries
Chemical & Metallurgical Engineering
Electrical World
Electrical Merchandising
Electrical West
Electronics

& Company

Business-Wrecking a Specialty

Whispering campaigns are particularly abundant—and particularly harmful—in times like these. For today people are ready to believe almost anything.

"That firm is slipping" may be idle gossip, but it might as well be the truth if you're doing nothing to convince your customers to the contrary.

"So-and-So has been taken over by the banks" is the kind of rumor that shakes customers' confidence and shifts orders to competitors.

"X and Company is going to merge with" isn't good talk to get around unless you really are planning to lose your identity—in which event, who cares?

There's one sure way to keep the gossip-distributors from picking on *your company.* That's to keep the world—and especially your customers—constantly reminded that you're not only in business but that you're out after business.

Let your customers and competitors know that there's the same pep in your organization now that there was in 1929. Let them know that your product is just as worth buying today as in 1929. Bring out those progressive merchandising ideas. Those new and improved products. Those aggressive sales and advertising plans.

Tell the world that you know there's still 60% of the normal business to be had—and you're out to get not only your share, but a good part of the business your fair-weather competitors are too frightened to go after.

That will give your competitors something to talk about—but not the kind of gossip they'd care to pass on to your customers.

Such advertising will leave your salesmen free to sell instead of chasing and fighting rumors. And, run in the McGraw-Hill Publications, it will cover your markets with the economy that is the order of the day.

PUBLISHING COMPANY, Inc.

Cleveland · Detroit · Chicago · St. Louis · San Francisco · Los Angeles · London

American Machinist
Product Engineering

Engineering News-Record
Construction Methods

Engineering and Mining Journal
(Domestic and Export Editions)

Metal and Mineral Markets
Coal Age

Transit Journal
Bus Transportation
Aviation

Textile World

Factory and Industrial Management
Maintenance Engineering
Power

The Business Week
Management Methods

Time and Money Saving Books

1. **ENGINEERING FOR MASONRY DAMS**
By William P. Creager
SECOND EDITION

Exceedingly useful for designers and practicing engineers. It is full of valuable information made easy of access by the orderly arrangement of the material. $4.00.

2. **THE DESIGN AND CONSTRUCTION OF DAMS**
By Edward Wegmann
EIGHTH EDITION

With a mathematical discussion and descriptions of multiple arch dams by Frederick A. Noetzli. Considered by engineers to be the outstanding book on this subject in print. Descriptions are given of every important dam in the world. $17.50.

3. **HYDRO-ELECTRIC HANDBOOK**
By W. P. Creager and J. D. Justin

The most valuable contribution to engineering literature on this subject. It should be in the hands of every engineer having to do with hydro-electric projects in any form. $8.00.

4. **WATER SUPPLY AND UTILIZATION**
By Donald M. Baker and Harold Conkling

An outline of hydrology from the viewpoint of the arid section of the United States, together with an outline of water law and its administration as it has been developed in the arid States. $6.00.

5. **SUSPENSION BRIDGES**
By D. B. Steinman
SECOND EDITION

A thorough study of the problems involved in designing, estimating and constructing suspension bridges, by a distinguished bridge engineer. $5.00.

6. **MERRIMAN'S AMERICAN CIVIL ENGINEERS' HANDBOOK**
FIFTH EDITION

A truly amazing compilation of current technical data—recent practice, new developments, new facts. Edited by Thaddeus Merriman, son of the original editor, and Thomas H. Wiggin, well-known consulting engineer. One volume edition, $8.00. Two volume edition, $10.00.

ON APPROVAL COUPON*

John Wiley & Sons, Inc.
440 Fourth Avenue, New York, N. Y.

Gentlemen: Kindly send me the books noted below. Within ten days after their receipt I will send you the price indicated or return the books postpaid.

.....

.....

Name .....

Address .....

Employed by .....

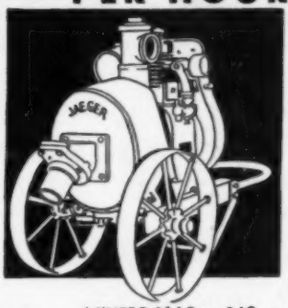
*This offer applies to residents of U. S. proper and Canada only.

CM 8-32

20,000 GALLONS PER HOUR

JAEGER 3" SELF-PRIME CENTRIFUGAL

100% automatic priming at lifts over 25 feet, heads up to 60 feet, 5 h. p. gas or electric power, weight only 400 lbs., Timken equipped. One of a complete line. Get our lower prices.



The JAEGER MACHINE Co.
800 Dublin Avenue Columbus, Ohio

MIXERS 3½ S to 84S.
HOISTS to 50 h. p.
PLACING EQUIPMENT.

JAEGER 10S - HANDLES LIKE A 7S

Fastest, easiest to handle 2 bagger, all-steel short coupled, with knuckle steering, roller bearing wheels. Water Regulator meets all state requirements

GET OUR LOW PRICES

Tilting, non-tilting Mixers, Contractors Pumps, Placing Equipment. Send for catalog.

The JAEGER MACHINE Co.
800 Dublin Avenue Columbus, Ohio

The Toledo Torch Prevents Accidents

always there-always lit-always seen •

Insist on the *genuine* Toledo Torch. No other safety light is so effective. Unbreakable, self-righting, stormproof, economical. Order through your dealer.

USE THE TOLEDO TORCH OR OTHER SIGNAL WHEN SAFETY

The Toledo Pressed Steel Co.
TOLEDO OHIO

Save with Steel

Manufacturers of The Toledo Horse—the ideal highway barricade

SEARCHLIGHT SECTION

EMPLOYMENT : BUSINESS : OPPORTUNITIES : EQUIPMENT—USED or RESALE

UNDISPLAYED—RATE PER WORD

Positions Wanted, 5 cents a word, minimum $1.00 an insertion, payable in advance.

Positions Vacant and all other classifications 10 cents a word, minimum charge $2.00.

Proposals, 50 cents a line an insertion.

INFORMATION:

Box Numbers in care of any of our offices count 10 words additional in undisplayed ads.

Discount of 10% if one payment is made in advance for four consecutive insertions of undisplayed ads (not including proposals).

DISPLAYED—RATE PER INCH:

1 inch.....$6.00
2 to 3 inches.....5.75 an inch
4 to 7 inches.....5.50 an inch

Other spaces and contract rates on request.

An advertising inch is measured vertically on one column, 3 columns—30 inches—to a page.

COPY FOR NEW ADVERTISEMENTS RECEIVED UNTIL 10 A. M. THE 27TH OF THE MONTH FOR THE ISSUE OUT THE FOLLOWING MONTH C.M.

POSITIONS VACANT

EXPERIENCED men seeking employment or positions offering larger or more varied opportunities will find an advertisement in the Positions Wanted column of assistance in securing consideration. Rate 5 cents a word.

WANTED

ANYTHING within reason that is wanted in the industry served by **Construction Methods** can be quickly located through bringing it to the attention of thousands of men whose interest is assured because this is the business paper they read.

AGENCIES WANTED

AGENCIES WANTED for cement, bricks, paint, waterproofing, concrete mixers, pumps, equipment. Arrow Construction Supply Co., 605 Somerset Road, Baltimore, Md.

WEMLINGER

STEEL SHEET PILING
SOLD — RENTED — BOUGHT
"A NATION WIDE SERVICE"

NEW YORK 500 Fifth Ave. | CHICAGO 228 No. La Salle St. | PHILADELPHIA 1015 Chestnut St. | BOSTON 31 State St. | RICHMOND 1708-1722 Lewis St. | TAMPA 315 Tampa St. | NEW ORLEANS 1105 Maritime Bldg. | HOUSTON 117 Eastwood St. | LOS ANGELES 2044 Santa Fe Ave

STEEL PILING
NEW and USED
MOST ECONOMICAL SECTIONS ROLLED.
STOCKS AT PRINCIPAL POINTS THROUGHOUT THE COUNTRY FOR PROMPT SHIPMENT.

BOUGHT — SOLD — RENTED — RE-PURCHASED
1 Length or 10,000 Every Length Guaranteed

L. B. FOSTER CO.
NEW YORK • PITTSBURGH • CHICAGO

EARN EXTRA MONEY
During Your Spare Time

How would you like to earn from $1 to $2 an hour for time now yielding you no profit. We have an exceptional position by which you can make money, spare or full time, without interfering with your present employment. You simply recommend and call to the attention of fellow employees and business men the most complete line of business and technical books ever published. Every kind of worker and business man finds in our books the ready reference knowledge that gives him the quick and valuable assistance in his daily work that will help him increase his daily earnings or his profits promptly and effectively and which once known about, he is eager to own. You can make ready cash quickly and easily each week by showing our lists to your associates and others. No experience required. Complete equipment, Free.

Write Tom Crawford, Dept. C. M.

McGRAW-HILL BOOK CO.
330 West 42d Street, New York City

The SEARCHLIGHT SECTION OF CONSTRUCTION METHODS

Represents the shortest distance between two points—the SELLER and the BUYER. It is the recognized national center for the sale or purchase of good used and surplus new equipment. The advertising rate is moderate and the results are usually more than satisfactory.

Address

DEPARTMENTAL ADVERTISING STAFF
330 West 42d St., New York

FOR SALE

Good as New--Rebuilt Equipment

Draglines, Tractors, Hoists, Etc.

1—P. & H. No. 600—1½-yd. Dragline, 40-ft. boom, 4 cyl. gas.
1—Koehring No. 601—1½-yd. Dragline, 45-ft. boom, 6 cyl. gas.
1—Koehring No. 501—1½-yd. Dragline, 40-ft. boom, 4 cyl. gas.
1—Northwest No. 700—1½-yd. Dragline, 50-ft. boom, 4 cyl. gas.
1—Koehring No. 501—1½-yd. Dragline, 40-ft. boom, Diesel engine.
4—Page Buckets—1½-yd. capacity.
1—P. & H. Bucket—1¼-yd. capacity.
9—60 Caterpillar Tractors.
1—60 Caterpillar Tractor with Bulldozer.
1—60 Caterpillar Tractor with Backfiller.
1—60 Best Tractor.
1—30 Caterpillar Tractor.
1—20 Caterpillar Tractor.
1—15 Caterpillar Tractor.
1—Bulldozer Attach. for 30 Caterpillar Tractor.
11—Cat Wagons (9—7 yd. and 2—5 yd.)
1—Buda-Ross Turbine Generator, 1000 watts.
1—Lidgerwood Steam Hoist No. 74.
1—Nove Hoist Outfit No. P-1353.
1—No. 4-SLS Lidgerwood 2-Speed Hoist, 10x12 Engine.
1—Dorsey Stump Puller Rig. No. 1566.
1—Complete 2-yd. Slack Line Tower Machine, Portable.

Ready to be loaded at East Prairie, Missouri.

THE POWELL-GAUEN CO., Charleston, Mo.

WHICH DO YOU PREFER?

CASH—IDLE EQUIPMENT

That surplus USED EQUIPMENT you have can be turned into CASH. The fact that it is of no further value to you doesn't mean it isn't of value to somebody else. There's always a market for good used equipment. Reach the greatest number of prospective buyers, at a minimum cost through the

SEARCHLIGHT SECTION

ALPHABETICAL INDEX TO ADVERTISERS

This index is published as a convenience to the reader. Every care is taken to make it accurate, but *Construction Methods* assumes no responsibility for errors or omissions.

American Cable Co., Inc. 48
American Steel & Wire Co. ....3rd Cover
American Surety Co. 58
Associated Manufacturers of Multi-Wall Sewn Paper Bags 12

Carnegie Steel Co. 51
Caterpillar Tractor Co. 4
Chain Belt Co. 14
Cities Service Company 9
Cleveland Tractor Co. 10-11
Crucible Steel Co. of America 13

Dietz Co., R. E. 53
Dorr Co., The 56

General Electric Co. 44-45-46
General Excavator Co. 54

Hydrauger Corp., Ltd. 56

Industrial Brownhoist Corp. 8
International Harvester Co. 57

Jaeger Machine Co. 62
Johnson Co., C. S. 59
Jules Racine & Co. 53

Leschen & Sons Rope Co., A. ..2nd Cover
Link Belt Company 3
Lowell Wrench Co. 54

Mack Trucks, Inc. ..... 4th Cover
Marion Malleable Iron Wks. 52
Martin-Decker Corp. 54

National Carbide Sales Corp. 47
New Mexico Construction Co. 49
Northwest Engineering Co. 5

Roebling's Sons Co., John A. 43

Searchlight Section 63
Shell Eastern Petroleum Products, Inc. 55

Toledo Pressed Steel Co. 62
Truscon Steel Co. 52-56

Vogt Bros. Mfg. Co. 64
Vulcan Iron Works 50

Westinghouse Electric & Manufacturing Co. 6-7
Wiley & Sons, Inc., John 62

▼ ▼ ▼

SEARCHLIGHT SECTION

Classified Advertising

Classifications — Page

Agencies Wanted 63
USED AND SURPLUS EQUIPMENT
Foster Co., L. B. 63
Powell-Gauen Co. 63
Wemlinger, Inc. 63

"The general business depression is stimulating research and development of new products, as well as more economic production and marketing methods."

SO says a well-known business economist—and nowhere is the truth of his statement more evident than in the engineering-construction field.

Keeping abreast of current developments in machines, materials and methods is a prime necessity for all who have a stake in the industry. The most important of these evolutionary improvements are recorded month by month in the advertising pages of Construction Methods.

Aer-O-Mix Head Tank and Discharge.

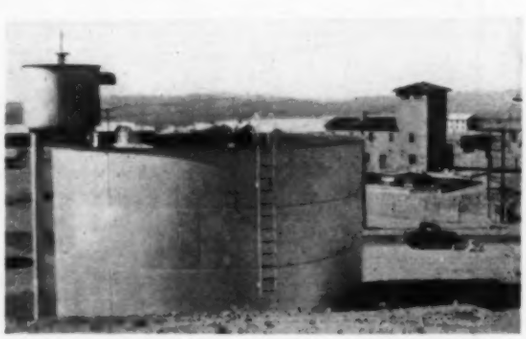
AER-O-MIX

Patented

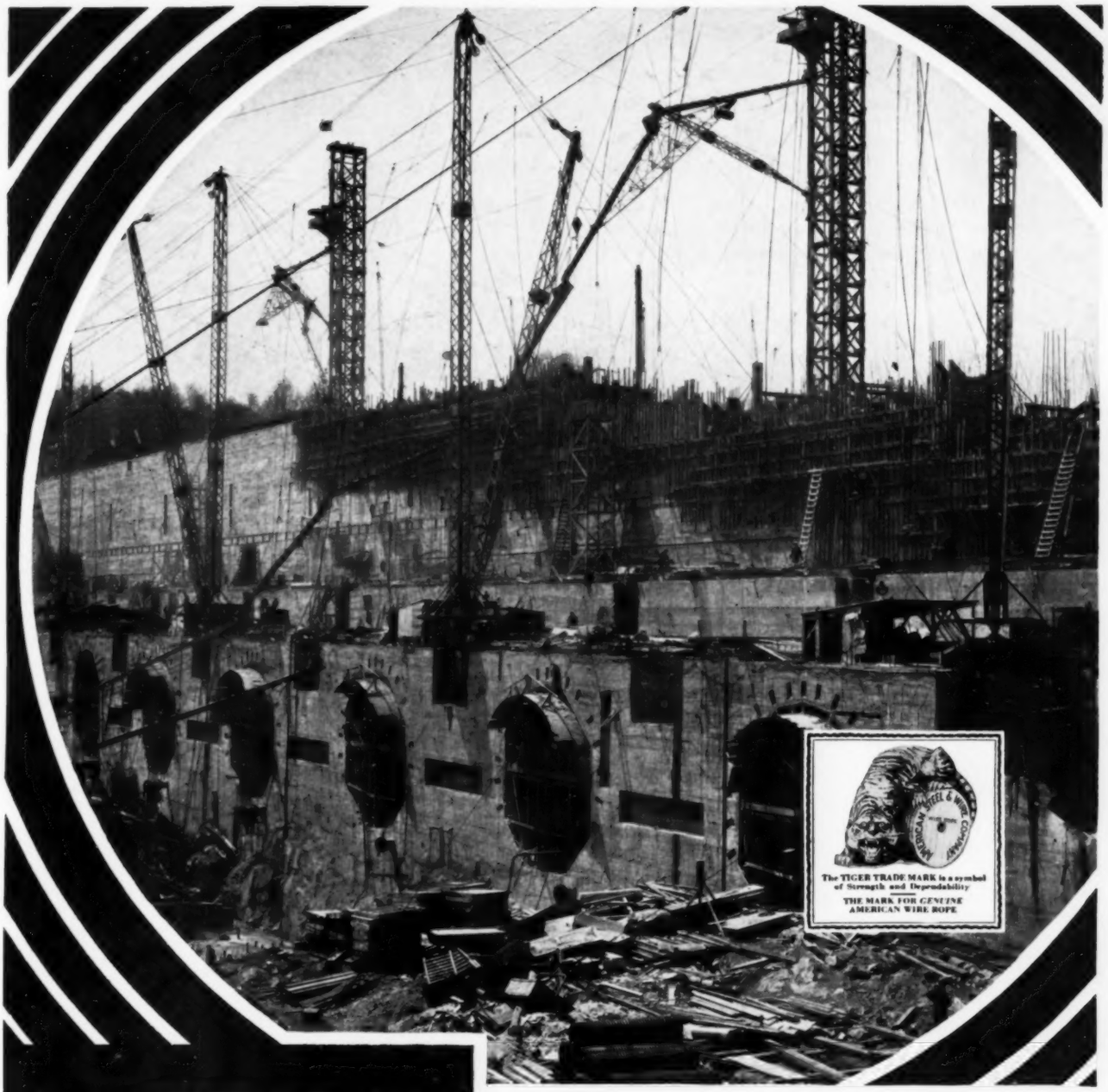
Aerator and Mixer is effectively reducing Hydrogen Sulphide and Carbon Dioxide gases in water supply at Boulder City, Nev. (Hoover Dam).

Manufactured by

VOGT BROTHERS MFG. CO.
INCORPORATED
LOUISVILLE · · KENTUCKY



Aer-O-Mix Head tank on top of steel discharge basin.



AMERICAN STEEL & WIRE COMPANY WIRE ROPE

Specified for the Difficult Tasks

Close to a half million feet of American Steel & Wire Company Monitor Silver Strand Wire Rope was used in connection with the vast project which is portrayed in the illustration. This enormous amount of Wire Rope included many different grades and sizes—and its application to various types of equipment was carefully supervised by our engineers.

Subjected to gruelling punishment and abnormal operating conditions, our product established unrivaled service records. Wherever the going is tough—be sure to use American Wire Rope for dependable service.

1831 MORE THAN 100 YEARS of PROGRESS IN WIRE MAKING 1932

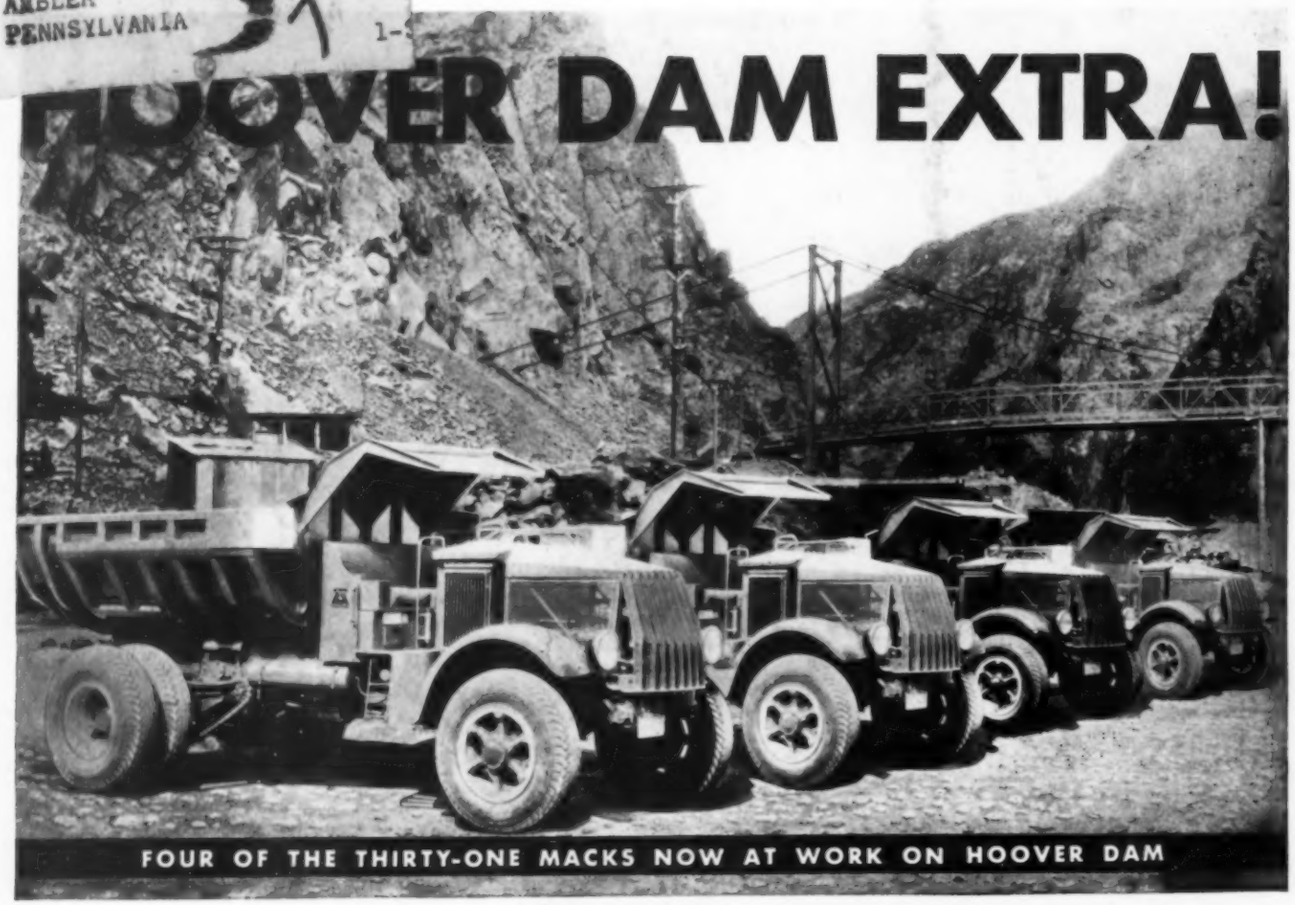
AMERICAN STEEL & WIRE COMPANY

208 South LaSalle Street, Chicago — SUBSIDIARY OF UNITED STATES STEEL CORPORATION — And All Principal Cities

Pacific Coast Distributors. Columbia Steel Company, Russ Building, San Francisco — *Export Distributors:* United States Steel Products Company, New York

WM S TWINING
AMBLER
PENNSYLVANIA

HOOVER DAM EXTRA!



FOUR OF THE THIRTY-ONE MACKS NOW AT WORK ON HOOVER DAM

Macks Escape Major Breakdowns

This Mack fell 125 feet, right side up, into the river. Within three hours it was back on terra firma with all damage repairable.

Heaping loads in their 14-yard bodies are the day and night diet of the super-duty Macks.

as trucks are literally torn to pieces on the toughest trucking job in history . . .

Performance counts again! Once more Macks demonstrate their superiority where the going is hard. Twenty-four hours a day Mack trucks are carrying capacity loads of rock and dirt under the severest hauling conditions ever encountered by trucks.

Yet not a Mack has suffered a single major breakdown. Not a single bent frame, cracked axle, broken transmission or rear-end, and no major engine trouble! Records show that Mack maintenance and hauling costs are the lowest on the job! No more decisive proof of the advantages of Mack ruggedness and stamina could be presented to the trucking industry.

The soundness of Mack design and the quality of the completely Mack-built truck are again proved by Mack performance on this truck-destroying job. The record has so impressed Six Companies, Inc., general contractors for the Hoover Dam, that they have placed orders for additional Mack units.

MACK TRUCKS, INC.
25 BROADWAY, NEW YORK, N.Y.

Mack